SUPPLEMENT
to
SOIL CLASSIFICATION SYSTEM
(7th Approximation)

SOIL SURVEY STAFF
SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
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p. 137 Haplic Vermudolls: at end of sentence, add "a".

p. 141 Lithic-Vertic Haplustolls should read "Haplustolls like the Typic except for f and h(2) with or without d or i or both."

p. 142 Vertic Haplustolls should read "Haplustolls like the Typic except for h(1) with or without all or any of b, d, or e."

p. 149 Typic Natrixerolls, item c, line 3, change 2.5 m to 2.5 cm.

p. 160 (Alfisols) First line should read "Alfisols are mineral soils that have no spodic or oxic horizon overlying an argillic horizon; that have no plinthite that forms a continuous phase within 30 cm (12 inches) of the soil surface; that"

Item 1, line 4, change "cm" to "m".

p. 165 Typic Cryoboralfs, change item a to read like item a of Typic Umbraqualfs, p. 164.

p. 169 Mollic Fraqiudalfs: change b to d.

p. 171 Andic Glossoboric Hapludalfs: change c to e.

p. 180 Typic Durixeralfs, item a, line 3 change 2.5 m to 2.5 cm.

p. 181 Aquultic Haploxeralfs: change f to g.

p. 46 Footnote, line 1, delete the two words "the Key".

p. 173 Aquultic Paleudalfs: change e to c

Mollic Paleudalfs: change c to e

Ultic Paleudalfs: change e to c

add p. 137 after Fluventic Haplustolls. ---- d with or without c.

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NOMENCLATURE

NAMES OF SUBORDERS AND GREAT GROUPS

The current names of the taxa in the orders, suborders, and great groups are shown in the table of names at the end of this chapter. The names initially proposed used the same prior formative elements in more than one category of some orders. This led to difficulty in naming subgroups. We have subsequently restricted the use of a given prior formative element to a single category in any one order. Spelling has been altered in the names of great groups having calcic horizons and fragipans by inserting the letter i to soften the final c of "calc" and the g for "frag" and "arg." These have become "calci," "fragi," and "argi."

The formative elements used for suborder and great group names and their derivations follow.

Formative Elements in Names of Suborders

Formative elements	Derivation of formative element	Mnemonicon	Connotation of formative element
alb	L. albus, white.	albino	Presence of albic horizon (a bleached eluvial horizon).
and	Modified from Ando.	Ando	Ando-like.
aqu	L. aqua, water.	aquarium	Characteristics associated with wetness.
ar	L. arare, to plow	arable	Mixed horizons.
arg	Modified from argillic horizon; L. argilla, white clay.	argillite	Presence of argillic horizon (a horizon with illuvial clay).
bor	Gr. boreas, northern.	boreal	Cool.
ferr	L. ferrum, iron.	ferruginous	Presence of iron.
fibr	L. fibra, fiber.	fibrous	Least decomposed stage.
fluv	L. fluvius, river.	fluvial	Flood plains.
hem	Gr. hemi, half.	hemisphere	Intermediate stage of decomposition.
hum	L. humus, earth.	humus	Presence of organic matter.
lept.	Gr. leptos, thin.	leptometer	Thin horizon.
ochr	Gr. base of ochros, pale.	ocher	Presence of ochric epipedon (a light-colored surface).
orth	Gr. orthos, true.	orthophonic	The common ones.
plag	Modified from Ger. plaggen, sod.		Presence of plaggen epipedon.
psamm	Gr. psammos, sand.	psammite	Sand textures.
rend	Modified from Rendzina.	Rendzina	Rendzina-like.
sapr	Gr. sapros, rotten.	saprophyte	Most decomposed stage.
torr	L. torridus, hot and dry.	torrid	Usually dry.
trop	Modified from Gr. tropikos, of the solstice.	tropical	Continually warm.
ud	L. udus, humid.	udometer	Of humid climates.
umbr	L. umbra, shade.	umbrella	Presence of umbric epipedon (a dark-colored surface).
ust	L. ustus, burnt.	combustion	Of dry climates, usually hot in summer.
xer	Gr. xeros, dry.	xerophyte	Annual dry season.

Formative Elements for Names of Great Groups

Formative element	Derivation of formative element	Mnemonicon	Connotation of formative element
acr	Modified from Gr. akros, at the end.	acrolith	Extreme weathering.
agr	L. ager, field.	agriculture	An agric horizon.
alb	L. albus, white.	albino	An albic horizon.
and	Modified from Ando.	Ando	Ando-like.
anthr	Gr. anthropos, man,	anthropology	An anthropic epipedon.

Chapter 4

Formative Elements for Names of Great Groups (Continued)

Formative element	Derivation of formative element	Mnemonicon	Connotation of formative element
aqu	L. aqua, water.	aquarium	Characteristic associated with wetness.
arg	Modified from argillic horizon; L. argilla, white clay.	argillite	An argillic horizon.
calc	L. calcis, lime.	calcium	A calcic horizon.
camb	L. L. cambiare, to exchange.	change	A cambic horizon.
chrom	Gr. chroma, color.	chroma	High chroma.
cry	Gr. kryos, coldness.	crystal	Cold.
dur	L. durus, hard.	durable	A duripan.
dystr, dys	Modified from Gr. dys, ill; dystrophic, infertile.	dystrophic	Low base saturation.
eutr, eu	Modified from Gr. eu, good; eutrophic fertile.	eutrophic	High base saturation.
ferr	L. ferrum, iron.	ferric	Presence of iron.
frag	Modified from L. fragilis, brittle.	fragile	Presence of fragipan.
fragloss	Compound of fra(g) and gloss.		See the formative elements frag and gloss.
gibbs	Modified from gibbsite.	gibbsite	Presence of gibbsite.
gloss	Gr. glossa, tongue.	glossary	Tongued.
hal	Gr. hals, salt.	halophyte	Salty.
hapl	Gr. haplous, simple.	haploid	Minimum horizon.
hum	L. humus, earth.		Presence of humus.
hydr	Gr. hydor, water.	hydrophobia	Presence of water.
hyp	Gr. hypnon, moss.	hypnum	Presence of hypnum moss.
luo, lu	Gr. louo, to wash.	ablution	Illuvial.
moll	L. mollis, soft.	mollify	Presence of mollic epipedon.
nadur	Compound of na(tr), and dur.		
natr	Modified from natrium, sodium.		Presence of natric horizon.
ochr	Gr. base of ochros, pale.	ocher	Presence of ochric epipedon (a light-colored surface).
pale	Gr. paleos, old.	paleosol	Old development.
pell	Gr. pellos, dusky.		Low chroma.
plac	Gr. base of plax, flat stone.		Presence of a thin pan.
plag	Modified from Ger. plaggen, sod.		Presence of plaggen horizon.
plinth	Gr. plinthos, brick.		Presence of plinthite.
quartz	Ger. quarz, quartz.	quartz	High quartz content.
rend	Modified from Rendzina	Rendzina	Rendzina-like.
rhod	Gr. base of rhodon, rose.	rhododendron	Dark-red colors.
sal	L. base of sal, salt.	saline	Presence of salic horizon.
sider	Gr. sideros, iron.	siderite	Presence of free iron oxides.
sphagno	Gr. sphagnos, bog.	sphagnum-moss	Presence of sphagnum-moss.
torr	L. torridus, hot and dry.	torrid	Usually dry.
trop	Modified from Gr. tropikos, of the solstice.	tropical	Continually warm.
ud	L. udus, humid.	udometer	Of humid climates.
umbr	L. base of umbra, shade.	umbrella	Presence of umbric epipedon.
ust	L. base of ustus, burnt.	combustion	Dry climate, usually hot in summer.
verm	L. base of vermes, worm.	vermiform	Wormy, or mixed by animals.
vitr	L. vitrum, glass.	vitreous	Presence of glass.
xer	Gr. xeros, dry.	xerophyte	Annual dry season.
sombr	F. sombre, dark	somber	A dark horizon.

NAMES OF SUBGROUPS

Subgroup names consist of the name of the appropriate great group modified by one or more adjectives. The adjective typic is used for the subgroup that is thought to typify the central concept of the great group.

Intergrade subgroups that have, in addition to the properties of their great group, some properties of another class carry the name of the other class in an adjective form. For example, assume a Cryorthent that has a B horizon too weakly developed to allow placing the soil in any order other than Entisol, but strongly enough developed to be recognizable. We shall assume that the aberrant properties in this soil are those that have been used to define a suborder in another order. The name of the subgroup therefore would be formed by modifying the great group name, Cryorthent, with the adjective form of the name of the appropriate suborder. If the very weakly developed B horizon were one in which illuvial humus had accumulated (as defined later for a spodic horizon and diagnostic for the suborder of Humods), the name of the subgroup would be Humodic Cryorthent. In this manner, the names of orders, suborders, or great groups, or any of the prior formative elements of these names, may be used in adjectival form for subgroup names. A few soils may have aberrant properties of two great groups belonging in different orders or suborders. For these, it is necessary to use two adjectival forms of class names in the subgroup name.

Naming of Intergrades Toward Other Great Groups in the Same Suborder

If the aberrant property of a soil is one which is characteristic of another great group in the same suborder, only the distinctive formative element of the great group name is used to indicate the aberrant properties. Thus, Typic Durargid is defined as having a platy or massive duripan that does not soften appreciably on wetting. If the only aberrant feature of a Durargid is that the duripan is brittle and has only about a third of its volume cemented into nodules called durinodes, it is considered to intergrade toward the Haplargids--the Argids that do not have duripans. The name, however, is Haplic Durargid, not Haplargidic Durargid. Only the prior formative element is used in adjectival form if the two great groups are in the same suborder.

Naming of Intergrades Toward a Great Group in the Same Order, but in a Different Suborder

Two kinds of names may be used to indicate intergrades toward a great group in the same order, but in a different suborder. If the only aberrant feature is one of color, with chromas that are too high or too low for typic subgroups, the adjectives aquic and aeric are used. These are shorter and in some instances more descriptive than the formative elements of the suborder or great group names.

Thus, if the only aberrant feature of a Hapludult is mottling that is too shallow for the Typic Hapludult, the adjective aquic is used in subgroup names. If mottling with low chromas appears within the upper 25 cm (10 inches) of the argillic horizon, the soil is called an Aquic Hapludult.

If an Aquult has chromas that are too high for the typic subgroups but no other aberrant feature, it is placed in an aeric subgroup. The use of an adjective taken from the suborder, udic, would not suggest that the difference was one of aeration alone.

In other instances the adjective in the subgroup name is made from the prior formative element of the appropriate great group name in that suborder. For example, if a Dystrochrept has an epipedon that approaches an umbric epipedon it may be considered to intergrade to the Umbrepts. It is called an Umbric Dystrochrept rather than an Umbreptic Dystrochrept.

Naming of Intergrades Toward Great Groups in Other Orders

If a Hapludalf has an epipedon that is too dark for a typic subgroup and approaches the properties of a mollic epipedon, the soil is considered to intergrade to one of the great groups of Mollisols. If the only aberrant feature is the nature of the epipedon, the soil is placed in the subgroup of Mollic Hapludalfs. This feature is the feature common to all Mollisols, and the prior formative element of the order name is used. If, in addition the soil should show mottles with gray colors in the upper part of the argillic horizon, it would be considered an intergrade toward the Aquolls and would be called an Aquollic Hapludalf. Note that this is simpler than Aquic Mollic Hapludalf. The general rule is that the simplest possible name is used.

Chapter 4

Table 9. Names of Orders, Suborders, and Great Groups

Order	Suborder	Great Group
Entisols (1)	Aquents	Cryaquents
		Haplaquents
		Hydraquents
		Psammaquents
		Tropaquents
	Arents	
	Fluvents	Cryofluvents
		Torrifluvents
		Tropofluvents
		Udifluvents
		Ustifluvents
		Xerofluvents
	Orthents	Cryorthents
		Torriorthents
		Troporthents
		Udorthents
		Ustorthents
		Xerorthents
	Psamments	Cryopsamments
		Quartzipsamments
		Torripsamments
		Udipsamments
		Ustipsamments
		Xeropsamments
Vertisols (2)	Torrerts	
	Uderts	Chromuderts
		Pelluderts
	Usterts	Chromusterts
		Pellusterts
	Xererts	Chromoxererts
		Pelloxererts
Inceptisols (3)	Andepts	Cryandepts
		Durandepts
		Dystrandepts
		Eutrandepts
		Hydrandepts
		Vitrandepts
	Aquepts	Andaquepts
		Cryaquepts
		Fragiaquepts
		Halaquepts
		Haplaquepts
		Humaquepts
		Plinthaquepts
		Tropaquepts
	Ochrepts	Cryochrepts
		Durochrepts
		Dystrochrepts
		Eutrochrepts
		Fragiochrepts
		Ustochrepts
		Xerochrepts
Inceptisols (3)	Plaggepts	
	Tropepts	Dystropepts
		Eutropepts
		Humitropepts
		Ustropepts
	Umbrepts	Anthrumbrepts
		Cryumbrepts
		Fragiumbrepts
		Haplumbrepts
		Xerumbrepts
Aridisols (4)	Argids	Durargids
		Haplargids
		Nadurargids
		Natrargids
		Paleargids
	Orthids	Calciorthids
		Camborthids
		Durorthids
		Paleorthids
		Salorthids
Mollisols (5)	Albolls	Argialbolls
		Natralbolls
	Aquolls	Argiaquolls
		Calciaquolls
		Cryaquolls
		Duraquolls
		Haplaquolls
		Natraquolls
	Borolls	Argiborolls
		Calciborolls
		Cryoborolls
		Haploborolls
		Natriborolls
		Paleborolls
		Vermiborolls
	Rendolls	
	Udolls	Argiudolls
		Hapludolls
		Paleudolls
		Vermudolls
	Ustolls	Argiustolls
		Calciustolls
		Durustolls
		Haplustolls
		Natrustolls
		Paleustolls
		Vermustolls

Table 9. Names of Orders, Suborders, and Great Groups (cont.)

Order	Suborder	Great Group
Mollisols (5)	Xerolls	Argixerolls
		Calcixerolls
		Durixerolls
		Haploxerolls
		Natrixerolls
		Palexerolls
Spodosols (6)	Aquods	Cryaquods
		Duraquods
		Fragiaquods
		Haplaquods
		Placaquods
		Sideraquods
		Tropaquods
	Ferrods	
	Humods	Cryohumods
		Fragihumods
		Haplohumods
		Placohumods
		Tropohumods
	Orthods	Cryorthods
		Fragiorthords
		Haplorthods
		Placorthods
Alfisols (7)	Aqualfs	Albaqualfs
		Fragiaqualfs
		Glossaqualfs
		Natraqualfs
		Ochraqualfs
		Tropaqualfs
		Umbraqualfs
	Boralfs	Cryoboralfs
		Eutroboralfs
		Fragiboralfs
		Glossoboralfs
		Natriboralfs
		Paleboralfs
	Udalfs	Agrudalfs
		Ferrudalfs
		Fragiudalfs
		Glossudalfs
		Hapludalfs
		Natrudalfs
		Paleudalfs
		Tropudalfs
	Ustalfs	Durustalfs
		Haplustalfs
		Natrustalfs
		Paleustalfs
		Plinthustalfs
		Rhodustalfs
Alfisols (7)	Xeralfs	Durixeralfs
		Haploxeralfs
		Natrixeralfs
		Palexeralfs
		Plinthoxeralfs
		Rhodoxeralfs
Ultisols (8)	Aquults	Fragiaquults
		Ochraquults
		Plinthaquults
		Tropaquults
		Umbraquults
	Humults	Haplohumults
		Palehumults
		Tropohumults
	Udults	Fragiudults
		Hapludults
		Paleudults
		Plinthudults
		Rhodudults
		Tropudults
	Ustults	Haplustults
		Paleustults
		Plinthustults
		Rhodustults
		Tropustults
	Xerults	Haploxerults
		Palexerults
Oxisols (9)	Aquox	Gibbsiaquox
		Ochraquox
		Plinthaquox
		Umbraquox
	Humox	Acrohumox
		Gibbsihumox
		Haplohumox
		Sombrihumox
	Orthox	Acrorthox
		Eutrorthox
		Gibbsiorthox
		Haplorthox
		Umbriorthox
	Torrox	
	Ustox	Acrustox
		Eutrustox
		Haplustox
Histosols (10)	Incomplete	

Argillic horizon--

Chapter 5

Significance of Argillic Horizons to Soil Classification

The argillic horizon by itself has little importance to soil classification. A taxon that included all soils with argillic horizons would have almost no other common property. Yet the horizon is a mark of the dominance of silicate clay translocation over processes that destroy or remove clay from the soil, and over processes that mix horizons. Because its formation is relatively slow, its presence indicates stability of the surface when undisturbed by man. Time has been ample on this stable surface to develop an apparent equilibrium between formation and decomposition of organic matter. Its presence indicates that a substantial amount of water has moved through overlying horizons, enough that soluble materials have been removed, though they may subsequently have been replaced. One might say that its presence is evidence that climate and vegetation have had opportunity to show their effects, though one may not say that this is true for the present climate and vegetation.

Taken in combination with other diagnostic features, the argillic horizon has much more meaning. In the desert environment it indicates a soil and surface of great age, for in the present environment rainfall is often not enough to moisten the soil to the base of the horizon.

On the steppes, the savannas, and the grasslands of subhumid climates, the argillic horizon is a useful means of distinguishing the surfaces of recent or very late Pleistocene age from the older surfaces. Its presence also correlates well with many other properties affected by leaching. In these relatively dry areas, the argillic horizon, in the absence of active mixing of horizons by soil fauna, seems to be a mark of soil age. As time passes, other things being equal, the argillic horizon becomes finer textured, and develops an abrupt upper boundary. Soils with fine textured B horizons and abrupt A-B horizon boundaries were the orthotypes of the soils called Planosols.

In cool humid regions the argillic horizon seems to be transient. It forms slowly, but with time it is moved deep into the soil and finally destroyed. In its place one finds the cambic or spodic horizons that are discussed later.

In humid temperate and tropical regions, the presence of the argillic horizon has still other meanings. In the humid temperate forested regions, the argillic horizon is mainly a mark of surface stability and of a seasonal moisture deficit. Its use helps distinguish the stable and unstable surfaces, as well as the soils with seasonal moisture deficits.

In humid tropics the argillic horizon appears to be useful in distinguishing many of the soils with some weatherable minerals from those formed in the old, completely weathered sediments. However, we have much to learn yet about these soils.

It needs to be stressed that the argillic horizon is no more important to soil classification and to soil genesis than many other horizons. It has been used at a higher categoric level in some parts of the system only because that use has produced groupings of soils with the largest number of common properties.

Appearance of the Argillic Horizon

The horizons of accumulation of illuvial clay that constitute argillic horizons have a variety of forms, and though positive identification is sometimes difficult, several features may be used for recognition in most soils. No one feature is common to all argillic horizons and lacking in all other horizons, but nearly all argillic horizons have at least two of the common features.

First, if there is an overlying horizon other than an Ap, the texture change between the eluvial and illuvial horizons is generally clear or abrupt. Sometimes it is gradual, and often it is irregular.

The argillic horizon is generally distinctly finer in texture than the overlying eluvial horizon or the underlying parent material. The ratio of the clay content of the eluvial and illuvial horizon is 1.2 or larger, and usually larger. The increase of 20 percent or more in the clay content usually occurs within a vertical distance of less than 6 inches (15 cm.). In a few soils the transition may take up to 12 inches (30 cm.). The lower boundary of the argillic horizon is often gradual, and irregular.

Second, there are usually coatings of oriented clay on the surfaces of pores and of peds somewhere within the horizon.

Third, the ratio of fine clay (less than 0.0002 mm.) to coarse clay is larger in the argillic horizon than it is in the eluvial horizons or in the horizons that underlie the argillic horizon.

Fourth, rock structure is not evident or is evident in less than half of the volume. Rock structure, in this context, refers to weathered rock in which the original shape and relative position of the altered minerals are still evident. Material is often called saprolite by soil scientists if it retains rock structure.

Argillic horizon--

In addition to the increased clay content and clay skins, we can expect the argillic horizon to have at least two other properties in this situation. The first property is thickness. Significant illuviation requires that the illuvial horizon have a reasonable thickness. An illuvial horizon 1 cm. thick underlying an eluvial horizon 50 cm. thick would not indicate a great deal of translocation. The illuvial horizon's thickness should be at least one-tenth that of the overlying horizons to indicate significant illuviation.

The second property is related to the transition from the eluvial horizon to the argillic horizon. The boundary may be abrupt or even gradual, but the clay content increases sharply enough that the limits for an argillic horizon are exceeded within a 12-inch vertical distance. To have an argillic horizon, the minimum increase in clay should occur within a 12-inch or thinner transition. It should be stressed that an increase in clay content with depth is not in itself evidence of an argillic horizon.

Stages of Degradation: Detailed studies of the micromorphology of some soils with argillic horizons (e. g., Glossoboralfs) show evidences that an argillic horizon may be formed and later destroyed. The clay skins are absent from the ped surfaces, and bleached coatings of silt or sand are left. Oriented clays within the peds persist for a time. It is possible, therefore, to have an argillic horizon undergoing degradation. Such a horizon has few or no clay skins on ped surfaces but has few or many oriented clay bodies within the peds. It is common in degrading horizons that the clay skins on ped surfaces or in pores are most abundant in the lower part of the argillic horizon and in the transition to the next underlying horizon. In advanced stages of degradation there may be no clay skins in or on the peds in the upper part of the argillic horizon.

The degrading argillic horizon shows evidence of degradation in addition to that indicated by absence of clay skins. It has an irregular upper boundary marked by narrow or broad penetrations of the eluvial horizon. Small nodular remnants of the argillic horizon are often found in the lower part of the eluvial horizon.

To summarize, if a horizon has an irregular or broken upper boundary it is considered an argillic horizon so long as it (1) retains a clay ratio of 1.2 or more with the overlying horizon; (2) has oriented clays in or on peds in the lower part; and (3) has an upper subhorizon with an irregular upper boundary that is not separated from the subhorizon with clay skins by an eluvial horizon (the albic horizon which is discussed later).

Identification in Sandy Soils

In sands and loamy sands, the argillic horizon often forms as a series of "fibers", or lamellae (fig. 12, p. 44). These are spaced at intervals ranging from a very few inches up to a foot or more. Only the lamellae are used for comparing textures and determining the thickness of the illuvial horizon. Obviously, a single lamella with a thickness of 2 mm. should not constitute an argillic horizon. It is too thin to indicate significant illuviation. Lamellae 1 cm. or more thick, and totaling something like 15 cm. or more in thickness, should be present for the recognition of an argillic horizon in sands and loamy sands.

Whether the argillic horizon is continuous or in lamellae, an arbitrary and somewhat higher ratio of the clay in the illuvial and eluvial horizons seems necessary in sandy soils. If the clay content of the parent material is only 1 percent, the movement of 10 percent of the clay from the surface horizon to an illuvial horizon would give clay contents of 0.9 and 1.1, respectively, if the two horizons had the same mass. Such a difference is too small to be detected in the field, or even in the laboratory by ordinary procedures. For this reason, an arbitrary difference of at least 3 percent of the total soil, the difference between 3 percent clay and 6 percent clay, has been selected as a division point for those soils having less than 15 percent clay in their surface horizons. With a difference of less than 3 percent clay between the eluvial and illuvial horizons, an argillic horizon is not recognized, although a B horizon may be readily discernible.

Identification in Fine-Textured Kaolinitic Soils

A ratio of the clay in the illuvial and eluvial horizons of 1.2 would require an unreasonable amount of translocation in parent materials rich in clay. A difference of 8 percent of the total fine earth fraction ordinarily should be detectable in clayey soils in the field and is easily measured in the laboratory. Consequently, if the surface horizon contains more than 40 percent clay, an increase of 8 percent or more in a subsurface horizon seems adequate for the recognition of an argillic horizon if the other characteristics of the horizon are present.

If the surface horizons are clayey, an argillic horizon is rarely obvious. Normally there is little or no color difference between the illuvial horizon and other horizons. Clay skins are difficult to see in the field because they have little contrast in texture with the matrix. They are also most susceptible to destruction in fine-textured horizons by pressure and by changes resulting from consolidation or fragmentation of peds that make for instability of ped surfaces. Even in the laboratory, uncertainty is great because pressures and stresses can produce clay orientation.

Spodic horizon--Cont.

According to newer theories an association is formed between organic matter and iron and aluminum by chelation and electrostatic bonding. Such compounds are soluble if the sesquioxide concentration is low and are precipitated when the sesquioxide concentration reaches a critical level. Hence, if soluble compounds moving through the soil pick up sesquioxides from primary minerals and from parts of the spodic horizon, they eventually precipitate somewhere in the spodic horizon. Such movement can be downward due to gravity or lateral or even upward due to capillary forces. Immobilization of the sesquioxides may also be the result of hydrolysis of the organic-metal complex induced by changes in pH or by biological destruction of organic ligands. Some of the specific properties of the immobilized material that becomes the active fraction of spodic horizons can be used as one of the means of identification. These properties are high concentration of carboxyl and hydroxyl sites that are destroyed on heating and solubilization of organic matter and sesquioxide compounds on treatment with a strong complexing agent (sodium pyrophosphate).

Distinctions between Spodic and Argillic Horizons

Argillic horizons are illuvial, and so are most spodic horizons. We think that discrete crystalline clay particles are moved from the eluvial to the illuvial horizon and within the illuvial horizon to form argillic horizons. Hence, in soils with argillic horizons, the clays in the eluvial and illuvial horizons are similar except when some one clay mineral moves preferentially to others. The silica-sesquioxide ratio for the whole soil is at a minimum in the argillic horizon but that of the clay fraction remains virtually constant throughout the profile. In soils with spodic horizons the dominant processes are dissolution of primary minerals in any eluvial horizon, movement of iron, aluminum, and organic matter, and precipitation of amorphous organic matter-metal complexes. Typically, the mineralogy of eluvial and illuvial horizons differs greatly and the silica-sesquioxide ratio in the spodic horizon is at a minimum both in the whole soil and in the clay fraction.

In mechanical analysis at least some of the illuviated iron and aluminum disperses and becomes part of the measured clay fraction[2/]. Hence, data commonly show a clay maximum in the spodic horizon. Both spodic and argillic horizons may be horizons of free iron accumulation. But in well-drained soils having argillic horizons the ratio of free iron to clay tends to be constant in all horizons, whereas in soils having spodic horizons this ratio tends to be variable.

In table 13, page 60, 7th Approximation, two soils with spodic horizons are compared to two soils with argillic horizons. All four soils have an albic horizon and have been considered Podzols by some. Descriptions of the soils and additional data are on pages 85 to 88. Although the silica-sesquioxide ratio of the whole soil has a minimum in both groups of soils, this ratio for the <0.002-mm fraction is approximately constant throughout in the soils with argillic horizons and highly variable in the soils with spodic horizons.

Micromorphology also shows that there are large differences. The birefringent crystalline clay coatings of the argillic horizon (fig. 6, page 39, 7th Approximation) differ sharply from the isotropic amorphous coatings of the spodic horizons (fig. 15, page 48). Most spodic horizons, however, contain some illuviated crystalline clay.

Distinctions between Spodic and Cambic Horizons

The cambic horizon is formed by alteration of parent material in place, causing release of iron and structure formation, or by solution and removal of carbonates; it is never an illuvial horizon but it may contain large amounts of precipitated active amorphous materials that are very similar to those of the spodic horizon. There are two situations where spodic and cambic horizons may be confused in the field. A cambic horizon may grade by imperceptible stages into a spodic horizon as a result of varying amounts of accumulation of amorphous materials. A very weakly developed spodic horizon, however, contains more active amorphous material than many cambic horizons, and the two kinds of horizon can be separated either on the basis of their micromorphology or by the chemical techniques described later. It may also be difficult to distinguish spodic horizons from the cambic horizons of soils developed in pyroclastic materials such as volcanic ash. Both horizons contain amorphous materials that do not differ significantly in the kinds of measurements we can make now. Both kinds of amorphous material may lose similar proportions of their cation-exchange capacity upon heating or extraction with dithionite-citrate.

The distinction between the spodic horizon and the cambic horizon with an amorphous active fraction (in soils formed in vitric materials such as volcanic ash) is based first on evidences of illuviation. Assume there is an overlying eluvial (albic) horizon that extends below plow depth as a continuous horizon or even as an intermittent horizon. In this situation we may safely infer that the underlying horizon is illuvial provided it meets the minimum requirements for extractable carbon, iron and aluminum relative to clay. The eluvial (albic) horizon should have chromas of 2 or less, or sand and silt grains that are dominantly clean, and it should be thick enough to insure that some part of the eluvial horizon extends below plow depth. A very thin eluvial horizon, only 1 to 3 cm thick, is apt to be accompanied by an illuvial horizon of comparable thickness and would not by itself indicate sufficient illuviation for a spodic horizon. It is apt to indicate only the beginning formation of a spodic horizon.

2/ The illuvial material of some spodic horizons disperses readily in one and not in another dispersing agent. Hence, different methods may give different results. In some spodic horizons the apparent silt accumulation is more pronounced than the clay accumulation.

Spodic horizon--Cont.

In the laboratory

Optical identification of amorphous material

Many spodic horizons can be identified with certainty by the presence of well-defined isotropic coatings (fig. 15, page 48, 7th Approximation) or of well-defined isotropic pellets (fig. 14, page 47). Some may be confused with argillic horizons if the coatings are weakly anisotropic in the part closest to an underlying sand grain or if there are significant inclusions of mica or other anisotropic clay minerals. Optical methods also may not be reliable if only diffuse pellets are present or if volcanic glass or other evidence of pyroclastic material leads one to suspect a cambic horizon that contains amorphous clay. In such cases the positive identification of spodic horizons may have to be based on chemical and physical methods.

Chemical identification

Some of the properties of the active amorphous material of spodic horizons such as high cation-exchange capacity, loss of exchange capacity on heating,[3/] and the presence of specific functional groups have been mentioned before. It would be desirable to define the spodic horizon by such properties. Some forms of organic matter and amorphous (allophane-like) material in some cambic horizons, particularly those developed in pyroclastic materials, have such similar properties that an exclusive definition of spodic horizon in these terms is impossible at this stage of our knowledge.

The spodic horizon is therefore defined here in terms of (1) 15-bar water retention, (2) percentage of pyroclastic material in the silt and coarser fractions and (3) solubility of its active components--organic matter, hydrated iron oxides, and hydrated aluminum oxides--in hot dithionite-sodium pyrophosphate relative to the clay content of the horizon:

1. The 15-bar water retention is <20 percent

2. Less than 60 percent of the 20 to 200 micron fraction (by weight) consists of vitric ash, pumice or other pyroclastic materials

3. $\dfrac{\text{percent extractable carbon + iron + aluminum}}{\text{percent clay}} \geq 0.15$

These conditions must be satisfied in any one subhorizon having enough extractable Fe, Al, or organic matter to satisfy the "other limits" discussed later. Carbon, iron, and aluminum (elemental concentration) are extracted by hot pyrophosphate-dithionite solution at pH 7.3; percentage of clay and silt are determined by the hexametaphosphate-pipette method.

Representative data for spodic horizons and selected cambic, argillic, and oxic horizons, as well as mollic and umbric epipedons, are given in Table A. Pyrophosphate-dithionite is used as the extractant to permit the carbon determination. Pyrophosphate-dithionite solution seems to be somewhat specific for the kinds of carbon, iron, and aluminum in the amorphous material. In spodic horizons usually more than half of the total carbon is extracted, whereas in the absence of amorphous (allophane-like) materials, less of the total carbon is extracted. In spodic horizons pyrophosphate-dithionite removes about as much iron as the dithionite-citrate method, but it removes only a small fraction of the dithionite-citrate-extractable iron from argillic, oxic, and some cambic horizons. The organic matter dissolved by pyrophosphate-dithionite may help to hold aluminum in solution. If solutions of aluminum salts are added to the extracting solution, aluminum pyrophosphate precipitates and no aluminum in solution is detected. Very little aluminum is extracted from gibbsite.

The amount of pyrophosphate-dithionite soluble carbon, iron, and aluminum and its ratio to clay permits the distinction between most spodic and other horizons that lack significant amounts of amorphous materials

Other limits of the spodic horizon

The amount of amorphous material in spodic horizons varies widely. It seems essential to set some lower limit for thickness of the horizon and its content of precipitated material. Spodic horizons below the plow layer should contain a subhorizon that is at least 1 cm thick and that contains at least 1 percent extractable organic carbon, iron, and aluminum (expressed on an elemental basis, not as oxides).

3/ Usually, the loss of CEC upon heating to 240° C. for 16 hours exceeds 25 percent for spodic horizons and is less than 25 percent for many other kinds of soil horizons (see Table A). This criterion would yield a satisfactory separation except for some very weakly developed horizons that have only traces of amorphous material, and cambic horizons with amorphous clays.

Spodic horizon--Cont.

The limit of 1 percent for extractable carbon, iron, and aluminum is waived, however if the moist value of the spodic horizon is 3 or less, the moist hue is 7.5YR or redder and is as red or redder than the underlying horizon. These colors indicate that coatings of humus and other amorphous materials on the sand and silt are more or less continuous.

A horizon is not a spodic horizon if it is so thin, so near the surface, and so weakly expressed that plowing a few times to a depth of 6 or 7 inches obliterates all traces. A horizon that could be or has been incorporated in a 6- or 7-inch plow layer may be considered spodic if there are no underlying diagnostic horizons other than a fragipan with or without an intervening albic horizon and the following limits are satisfied:

a. at least 3 percent organic matter (1.7 percent carbon) in the plow layer;
b. a moist color value of less than 3 and a hue redder than 10YR, or a chroma of 3 or more;
c. fragments of amorphous coatings or pellets;
d. no underlying diagnostic horizon other than a fragipan or an albic horizon, or both.

The fact that a spodic horizon is continuous on one side of a fence or property line is not evidence that the Ap horizon on the other side of the fence includes a spodic horizon. If the land use pattern has been stable for some scores of years, a spodic horizon may have formed in the noncultivated soil under its present vegetation or, due to liming or other management practices, the Ap horizon may have lost most of the properties of a spodic horizon.

Summary of the Limits of the Spodic Horizon

1. If there is an albic horizon thicker than 18 cm (7 inches) or there is an intermittent albic horizon below an Ap a spodic horizon has:

a. Enough amorphous material that

$$\frac{\text{4/ percent extractable C + Fe + Al}}{\text{percent clay}} \geq 0.15$$

b. A thickness of 1 cm or more, either as a continuous horizon or as a sum of lamellae within 1 m (40 inches);

c. Extractable 4/ carbon + iron + aluminum $\geq$ 1.0 percent, or moist color hues are 7.5YR or redder and moist values of 3 or less in some continuous part of the horizon or in any one subhorizon that is at least 1 cm thick and hues are as red or redder than the underlying horizon.

2. If an O, an Ap, or an A1 rests on the spodic horizon, the spodic horizon has the requirements of 1. above, and in addition has:

a. A 15-bar water content of less than 20 percent;

b. Less than 60 percent of vitric volcanic ash, pumice and other pyroclastic materials in the 20 to 200 micron fraction;

c. Enough depth that the horizon is not obliterated by plowing to 18 cm (7 inches) or enough degree of expression that the horizon after mixing to 18 cm (7 inches) meets the criteria listed under 3.

3. If an Ap is present and is not underlain by a diagnostic subsurface horizon other than a fragipan, with or without an albic horizon, the Ap is considered a spodic horizon if it has the following properties:

a. Contains more than 3 percent organic matter (1.7 percent organic carbon);

b. $\frac{\text{4/ percent extractable C + Fe + Al}}{\text{percent clay}} \geq 0.20$;

c. Fragments of amorphous coatings or pellets can be clearly identified;

d. The hue is redder than 10YR and the moist color value less than 3, or the chroma is 3 or more in hues of 10YR or redder;

e. A 15-bar water content of less than 20 percent;

f. Less than 60 percent of vitric volcanic ash, pumice and other pyroclastic materials in the 20 to 200 micron fraction.

4/ Elemental weight percent by pyrophosphate-dithionite extraction.

TABLE A. Change in cation exchange capacity and loss of C, Fe, and Al on various treatments of selected diagnostic horizons

Soil series[1] and suborder	Horizon	15-bar H_2O Pct.	Clay[2] percent	Org. carbon[3]	Dry[4] CEC meq/100 g[5]	240°C CEC meq/100 g[5]	CEC Change on Heating Pct.	C Extracted Pct.	Fe Extracted Pct.	Al Extracted[6] Pct.	C + Fe + Al[7] Pct. Clay
Camroden Orthod	Spodic	19.2	22.2	6.65	76.2a	25.2	-67	4.00	2.67	1.00	0.35
Paxton Orthod	Spodic	12.9	6.9	5.79	48.1a	9.8	-80	4.38	1.48	1.42	1.06
Potsdam Orthod	Spodic	7.8	14.7	0.79	12.9a	9.4	-27	.51	1.09	.69	.16
Windsor Orthod	Spodic	3.9	2.8	.54	6.5a	4.7	-28	.27	.46	.37	.39
Leon Aquod	Spodic	1.9	1.7	1.13	10.9	6.9	-37	.92	.02	.12	.62
"Antwerp" Humod	Spodic	8.3	1.1	3.46	19.4a	3.5	-82	2.51	.30	.24	2.77
"Kanto" Andept	Umbric epipedon	50.0		7.5	57.9a	41.5	-28	2.16	2.13	1.55	
Waimea Andept	Mollic	59.2		3.21	104.7a	94.9b	-9	1.57	2.49	.93	
Nipe Oxisol	Oxic	24.8	59.6	1.33	17.1	16.1	-6	.74	4.76	.95	.11
Hayesville Udult	Argillic	19.4	42.8	.38	6.8	8.7	+28	.22	2.12	.45	.07
Diablo Xerert	Mollic epipedon		47.4	.92	40.9	38.2	-7	.63	.37	.10	.02
Stockbridge Ochrept	Cambic	8.0	23.0	.27	8.9	8.2	-8	.17	.98	.20	.06
Brinkerton Aqualf	Argillic	17.2	35.6	.62	25.0	21.0	-16	.39	2.18	.30	.08

1/ Soil series names are uncorrelated field names subject to change. "Antwerp" and "Kanto" indicate neighborhood of samples.

2/ Hexametaphosphate-pipette determination.

3/ Walkley-Black or Allison (SSSAP 24:36, 1960).

4/ Air dry unless otherwise noted.

a. Field Moist

b. 200° C.

5/ Based on weight of untreated sample dried at 110° C.

6/ Pct. pyrophosphate-dithionite extracted (one treatment), pH 7.3.

7/ Percent C + Fe + Al (elemental weight percent by pyrophosphate-dithionite extraction).

Chapter 5
THE CAMBIC HORIZON

The Genesis

The cambic horizon is an altered horizon having texture finer than loamy fine sand. The alteration of the cambic horizon is produced by movement of the soil particles by frost, roots, and animals to such extent as to destroy most of the original rock structure including fine stratification of silt, clay, and very fine sand in alluvial or lacustrine deposits, by aggregation of the soil particles into peds, and in addition by (1) hydrolysis of some of the primary minerals to form clays and liberate sesquioxides, or (2) solution and redistribution or removal of some carbonates, or (3) oxidation, reduction and segregation, or removal of free oxides.

The cambic horizon has lost sesquioxides or bases, including carbonates, or both through leaching. Gains may have occurred in organic matter and water, but the alteration of the cambic horizon is not the result of additions of mineral substances.

The cambic horizon may be at the surface if there is no A1 horizon. Otherwise, it is immediately below one of the diagnostic epipedons. It is considered a part of the solum and occurs within the zone normally reached by the roots of native plants. Thus, it normally lies in the position of a B horizon, and by many it is considered to be a B horizon. Its base must be at least 25 cm (10 inches) below the surface.

Below many argillic and spodic horizons there is a transition to the C in which there has been weathering and alteration. The alteration of this transitional horizon may be comparable to that of a cambic horizon. Yet, because there is an overlying argillic or spodic horizon, a transitional horizon of this kind is not considered a cambic horizon. Rather, it is considered a transition to the C horizon. This distinction, which may seem very fine, is primarily one of position in the profile; the cambic horizon occupies the position of a B horizon, between the A and C, and not the position of a transition between a spodic or argillic horizon and the C.

Similarly, there may be transitional horizons (A3 and B1), between the A and an argillic horizon, that have properties of a cambic horizon. Such horizons are not considered part of a cambic horizon if they rest directly on the argillic horizon, but they are considered transitional horizons. Nevertheless, a cambic horizon may be recognized in the same profile as an argillic horizon or a spodic horizon if the two are separated by another diagnostic horizon discussed later, the albic horizon, or if the argillic horizon is a buried horizon. Thus we see that position and alteration without illuviation are important characteristics of the cambic horizon.

Identification of the cambic horizon

The cambic horizon may have one of several somewhat contrasting forms, but each of these grades at times imperceptibly into the others. The genetic significance of the cambic horizon varies somewhat with the kind of soil. It consistently carries the implication of a subsurface horizon that has been altered without mineral accumulation. The degree of alteration may vary, but some weatherable minerals* are present. One could define the several kinds of cambic horizons and give them distinctive names, but the limits of the transitional forms would be difficult to understand. The possible benefits do not seem to justify the complication that would have to be introduced if one tried to distinguish clearly between the transitional forms. Nevertheless, it is important to understand that cambic horizons vary in appearance and in genetic significance. We should look at the typical forms that the cambic horizon may have under varying combinations of the soil-forming factors.

1. Cambic horizons may form in the presence of fluctuating ground water. If ground water is present in the horizon at all times, the colors will usually be neutral, or will be shades of green or blue. These colors are excluded from the cambic horizon on the assumption that losses are negligible in the presence of a permanent ground water. If ground water fluctuates, the free iron is generally removed from the individual particles of sand, silt, and clay. This iron is either lost from the horizon or concentrated in the form of concretions or mottles. Gray or grayish and brownish mottled horizons are produced by fluctuating ground water. However, mottling alone is not an evidence of sufficient alteration for identification of a cambic horizon. The processes of reduction, or of reduction and segregation, of the iron must have been intense enough to produce a horizon dominated by low chromas. The horizon must have an upper boundary that is shallower than 50 cm (20 inches), or it must immediately underlie an umbric or mollic epipedon. It must have dominant moist colors on ped faces, if peds are present, or in the matrix if peds are absent, as follows:

   a. If there is mottling, chromas are 2 or less.

   b. If there is no mottling and values are less than 4, chromas are less than 1; if values are 4 or more, chromas are 1 or less.

   c. Hues no bluer than 10Y if the hue changes on exposure to air. ** (Hues that do not change on exposure are not diagnostic).

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*Weathering may be either chemical or physical. Kaolinite books of silt or sand size can be reduced to clay size and in this sense are weatherable. Feldspars can be altered chemically and are therefore weatherable.

** Color changes on exposure are ordinarily visible within a few minutes. Simply expose a moist clod briefly and then break the clod to compare the interior and exterior colors.

Weathering may have affected the easily weatherable minerals. The weathering may have removed lattice iron or have formed secondary clay minerals, but weathering has not progressed to the point where virtually the only minerals present are clay-sized kaolin minerals, free sesquioxides, and quartz and other forms of SiO_2. Soil 37, p. 119, does not have a cambic horizon because it has the green and blue hues that indicate a permanent ground water. But soil 38, p. 120, has a cambic horizon formed with a fluctuating ground water.

2. In the absence of ground water and of carbonates, cambic horizons in soils of humid regions normally have brownish colors; the chroma, because of liberation of free iron oxides, commonly is stronger or the hue redder in the cambic horizon than in the C. Feldspar minerals, and such easily weatherable minerals as glass, biotite, some pyroxenes, and some amphiboles, are commonly partly weathered. Mica, if it is present, is usually at least partly weathered to 2:1 lattice clay. These minerals and kaolin books of silt size have not been completely destroyed in the cambic horizon. The hydrated oxide of iron removed from primary minerals may have formed coatings on individual soil particles and is considered to be responsible for the color of the horizon if it is brown or red. The free iron/clay ratio is virtually constant among subhorizons of these cambic horizons, in contrast to those formed in the presence of ground water.

Because considerable time is required for the partial destruction of iron-bearing minerals or the formation of clay, the cambic horizon has had time to develop blocklike or prismatic structure, but such structure may be lacking if the clay content is so low that there is no volume change with changes in soil moisture.

Since illuviation is negligible, the peds lack distinctive coatings and generally are weakly developed. Preferred alignment of plate-shaped particles parallel to the ped face can be demonstrated in thin sections (fig. 9, p. 42) on many smooth ped faces.

The microfabric (fig. 9) of this form of the cambic horizon often resembles that of the argillic horizon in having random orientation of individual particles and little pore space in the matrix. It differs from an argillic horizon in lacking, in all subhorizons, clay skins that are of distinctly finer material than the matrix. Under crossed polarizers, the brightness of the interference color (birefringence) on the faces of peds in a cambic horizon indicates a preferred orientation of particles. Although the ped faces show evidence of preferred alignment of plate-shaped particles, they differ from clay skins in that the particles are less perfectly arranged and are similar or identical to the ped interiors in particle-size distribution. The cambic horizon may have an occasional clay skin, but evidences of clay illuviation are not adequate for recognition of an argillic horizon.

Table 14 contains selected data on three profiles that have cambic horizons. In profile 24, the cambic horizon overlies a lower sequum containing an eluvial horizon and a fragipan. The profile description, profile No. 24, is on page 89. It will be noted that the cambic horizon, from 2 to 16 inches, contains more free iron but less total iron and less "lattice" iron than the underlying horizons. Lattice iron is not an entirely correct name, for it includes magnetite. Clay mineral analyses show some weathering of micas and chlorite to vermiculite. The cambic horizon in this profile has appreciably more clay than the overlying A2 or the underlying eluvial horizon, A'2. It could therefore be confused with an argillic horizon. This is an extreme example. More commonly the cambic horizon either has less clay or has at the most 2 or 3 percent more clay than the A. There are, however, no evidences of significant clay illuviation in profile 24. Clay skins are so few and so thin that they are not seen by field examination. Thin sections show the presence of a very few very small clay skins in pores. The total analyses indicate the clay has been largely formed in place, for the B is intermediate in its silica-sesquioxide ratio between the A and C. Both spodic and argillic horizons (table 13) have the minimum silica-sesquioxide ratio, on the basis of the fraction less than 2 mm. for the profiles in which they occur. Distinctions between spodic and cambic horizons that contain active amorphous materials are discussed under the spodic horizon.

Profile 33 is a soil with a mollic epipedon above the cambic horizon. The data suggest the beginning of an argillic horizon, from 9 to 15 inches, in the mollic epipedon. The cambic horizon, from 15 to 34 inches, shows no evidence of being an illuvial horizon, but does show evidences of formation of clay, as the clay content decreases steadily with depth.

Profile 34 is a soil with an ochric epipedon and a cambic horizon. The cambic horizon, from 2 to 13 inches, shows loss of both iron and aluminum, but no evidence of illuviation.

All these profiles, 24, 33, and 34, have significant amounts of weatherable minerals in the silt and sand fractions. Evidence may be seen in the appreciable contents of K_2O in all profiles, and the CaO in profiles 24 and 33.

3. The cambic horizon that forms in humid climates from highly calcareous materials may show a granular or crumb structure produced by soil fauna. Earthworms, in particular, are often active in temperate and warm climates in mixing material from different horizons. Consequently, the soil is often calcareous throughout, even though there has been a considerable loss of carbonates. In calcareous materials, evidences of weathering of feldspars and other silicate minerals may be slight or absent. There is evidence of the loss of carbonates either in the form of limestone ghosts or solution pitting of limestone pebbles, or the carbonate content gradually increases with depth. In addition, the clay content usually shows a gradual decrease with depth.

Chapter 5

OXIC HORIZON

The oxic horizon is an altered subsurface horizon at least 30 cm (12 inches) thick consisting of a mixture of hydrated oxides of iron or aluminum, or both, often amorphous, and variable amounts of 1:1 lattice clays and accessory highly insoluble minerals such as quartz sand. Its fine-earth fraction has little or no 2:1 lattice clay or primary minerals that can weather to release bases, iron or aluminum. For each 100 grams of clay that it contains, the fine earth holds 10 meq or less of cations from 1N NH_4Cl solution and has a cation-exchange capacity by NH_4OAc of 16 meq or less. The oxic horizon has a lower exchange capacity or smaller amounts of minerals that can weather physically or chemically than the cambic horizon. It differs from the argillic horizon in having few or no clay skins and in having either a gradual or diffuse increase in clay content with depth, or no increase. Its upper boundary is set at the least depth at which there is no water-dispersible clay. For diagnostic purposes, its lower boundary is usually set at a depth of 2 meters. These properties and limits are discussed later in more detail.

Genesis

Geomorphologic evidence shows that oxic horizons are generally in soils of very old stable geomorphic surfaces, old in the sense that they are more apt to be mid-Pleistocene or earlier than late- or post-Pleistocene. They are not in soils of recent surfaces with thin regolith.

If quartz or ironstone pebbles are present, stone lines in or under the oxic horizon are normal. Stone lines are so common that one must consider it probable that oxic horizons are mainly in very old transported sediments. Quartz veins can be traced from deep layers through cambic or argillic horizons, but the authors have not yet seen them in oxic horizons. It should be noted, however, that quartz veins are very rare in Hawaii and Puerto Rico where we have studied oxic horizons most.

Whatever the materials, the great age of the oxic horizon has allowed time for mixing by animals and plant roots so that it retains almost no vestige of the original rock structure either as fine stratifications or saprolite. One exception only is found to this; If iron oxides or gibbsite coat and cement fragments of weathered rock, the original rock structure may be retained in the interior of the cemented parts but not in the fine earth. Pseudomorphs of olivine tend to persist but are not considered indicators of lack of weathering.

The age of the oxic horizons is such that minerals weatherable in warm humid climates are absent or are present only in traces. There is, therefore, no reserve of bases beyond those in the exchange fraction and in plant tissue.

Oxic horizons are seldom found outside tropical or subtropical climates, and there they are mainly at elevations below 1,500 to 2,000 meters. However, within that zone their distribution is largely independent of rainfall, suggesting that many formed under much higher rainfall than they receive today.

Most of the soils with oxic horizons are nearly level or have relatively gentle slopes; relief is commonly only a few tens of meters. They occur mostly on old high-level surfaces, high terraces, and pediments. The geomorphic position is one in which weathered sediments could have been deposited. It is not one in which recent unweathered sediments could accumulate, nor is it one that would receive ground water that has moved laterally from an area where fresh rock is weathering.

Significance to soil classification

The oxic horizon is considered important to soil classification. Although much remains to be learned about its genetic significance, it is important that weathering has been so extreme that virtually the only remaining minerals are quartz, zircon, and similar highly insoluble primary minerals, hydrated iron and aluminum oxides, and 1:1 lattice clay minerals. Yet there is little or no evidence that clay is moving in the soil. This suggests a high order of stability or immobility of the clay fraction. Stability is further suggested by the absence of water-dispersible clay in all oxic horizons that have a net negative charge as well as by the great resistance to erosion.

There are few or no primary minerals that release bases on weathering. The low activity of the clay limits the supply of bases held at exchange sites. Other nutrients, such as phosphorus, are often in forms not available to plants. In humid regions, the nutrients essential for plant growth often are largely in the living and dead tissue of plants and can be lost if the plant cover is burned and not allowed to regenerate. Calcium can be so low as to be a barrier to root growth, particularly of annual plants. Thus, soils with oxic horizons have unique management requirements that stem from the low activity of the clay, high permeability, low erodibility, extreme weathering, and low reserve of bases in the oxic horizon.

micas. Colors may be rather uniform in some saprolites from acidic rocks, but the materials have obviously been altered in place without appreciable disruption of the fabric. Saprolite may underlie an oxic horizon but should constitute no more than about 5 percent by volume of the oxic horizon. The presence of more than 5 percent by volume of saprolite within 2 meters commonly marks the lower boundary of the oxic horizon. Similarly, sand-size kaolin crystals or "books" that smear between the fingers into micalike flakes of sand size should be rare or absent in any subhorizon of the oxic horizon because they too are remnants of original rock structure. Pseudomorphs of olivine, mentioned earlier, may be present.

Color is not diagnostic. Oxic horizons may have varying shades of gray, brown, and red, or there may be mixtures of these colors in medium or coarse patterns of mottles.

The percentage of clay in an oxic horizon can increase, decrease, or remain constant with depth. Horizons of different texture can have clear boundaries if separated by a stone line. Otherwise, changes in the percentage of clay with depth are gradual. If there are clay skins in pores and on peds somewhere within the soil, the relative clay[1] increase within a vertical distance of 12 inches (30 cm) is less than that required for the argillic horizon. Particularly, the oxic horizon has no clear boundary with an overlying horizon that contains distinctly less clay throughout. Such a boundary is one of the marks of argillic horizons, and if it is present, one should look carefully for clay skins. Clay skins may be present only at depths of more than a meter where roots are scarce, but if they occupy more than 1 percent of the volume of any subhorizon, they indicate the presence of an argillic horizon[2]. Clay skins may be present in oxic horizons, but they should be very few and be restricted mainly to pores. Pressures from swelling may produce peds with smooth reflective faces in oxic horizons. If the texture is fine, these faces resemble clay skins. Laboratory study of such faces and of clay skins can help one learn to distinguish between them in the field (see Argillic Horizon).

In the laboratory

Identification of an oxic horizon in the laboratory usually requires one or more of the following measurements: (1) percentage of weatherable minerals in the sand fraction, (2) particle-size distribution or water held at 15-bars tension, or both, (3) base retention from 1N NH_4Cl solution, or in noncalcareous soils, the sum of extractable bases and KCl-extractable aluminum, (4) exchange capacity at pH 7 (by NH_4OAc), (5) percentage (by volume) of clay skins identifiable in thin sections, (6) percentage of clay dispersible in water, and (7) identification of clay minerals.

Petrographic examination. Feldspar, glass, and ferromagnesian minerals should constitute less than 3 percent of the fraction between 20 and 200 microns. Mica (muscovite) may constitute as much as 6 percent of this fraction.

Particle-size distribution. A reliable estimate of the amount of clay in an oxic horizon is essential for estimating the cation-exchange capacity of the clay. Particle-size distribution is usually determined by the pipette method using sodium hexametaphosphate as a dispersing agent and reciprocal or end-over-end shaking. But some oxic horizons have silt- and sand-size aggregates of clay that do not disperse but contribute to the exchange capacity. An independent measure of clay content is therefore necessary, and the water retained at 15 bars affords such an estimate. The ratio, $\frac{\text{percent 15-bar water}}{\text{percent clay}}$, does not exceed 0.5 if the clay disperses. Ratios of 0.4 are most common in oxic horizons. If there is appreciable cementation, removal of free sesquioxides by citrate-dithionite permits reasonably complete dispersion. In limited trials using samples that had ratios of 15-bar water to clay of 0.7 and 0.9 respectively, the ratio was reduced to 0.5 by treating as total clay the sum of the material extracted by citrate-dithionite and the clay that dispersed after the citrate-dithionite treatment. In general, the value of 2.5 x 15-bar water seems to give the best estimate of the clay percentage in horizons having a pH-dependent cation-exchange capacity low enough to exclude the possibility of an appreciable amorphous component (allophane) in the clay fraction. We use the higher of the two methods, either 2.5 x 15-bar water or the clay percentage measured by pipette.[3]

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[1] Clay by the pipette method.

[2] We should note that clay skins are commonly abundant in saprolite below an oxic horizon, but their presence in the saprolite is not a mark of an argillic horizon.

[3] Pipette method without citrate-dithionite extraction. Data on particle-size distribution after citrate-dithionite extraction are too few at present to make the method useful for classifying soils. When and if more data are accumulated, the limits on cation-exchange capacity per 100 grams clay may need to be re-examined.

Table C. Selected characterization data for oxic, argillic, and cambic horizons (Nd, no data; - none detected)

Soil	Horizon	Organic carbon	Clay	15-bar water	Extractable cations		Cation-exchange capacity of clay				
					Al^{+++}[1]	Total[2] bases	NH_4Cl[3] pH 7	NH_4Cl[4] unadj.	Perm.[5] charge	NH_4OAc	Sum[6]
			Percent		meq/100 g soil		meq/100 g clay or 2.5 x 15-bar H_2O[7]				
Pooku (Hawaii)	Oxic	1.6	nd.	36.0	0.2	0.2	nd.	0.7	0.4	5.2	nd.
Delicias (P. R.)	C2 Saprolite	.2	42.2[8]	26.5	-	3.3	5.0	4.8	5.0	6.9	16.5
Catalina (P. R.)	Oxic	1.2	82.1	32.3	2	2.0	9.5	6.2	5	10.7	24.0
Haiku (Hawaii)	Argillic[9]	2.0	nd.	38.1	0.4	1.3	nd.	6.8	1.8	16.3	nd.
Cialitos-like (P. R.)	Argillic[10]	2.0	81.8	34.1	8.1	2.1	22.4	15.3	12.0	23.3	35.8
Limones (P. R.)	Argillic	.3	47.4	22.6	4.3	1.1	12.7	9.9	9.6	14.9	22.5
Waihuna (Hawaii)	Cambic[10]	.2	nd.	32.1	-	20.3	nd.	26.5	25.4	27.6	nd.
Astoria (Oregon)	Cambic[10]	.5	41.6[8]	29.7	32.8	1.4	54.8	45.4	46.1	nd.	64.5
Honakaa (Hawaii)	Cambic[9]	5.1	nd.	135	-	0.7	nd.	7.7	0.7	23.0	-
Quillayute (Oregon)	Cambic[9]	1.6	18.1[8]	23.8	1.3	1.2	38.5	13.4	4.2	nd.	54.4

[1] 1N KCl-extractable.

[2] NH_4OAc-extractable bases.

[3] pH adjusted with NH_4OH; 1N NH_4Cl.

[4] 1N NH_4Cl; unbuffered.

[5] NH_4OAc-extractable bases plus 1N KCl-extractable aluminum.

[6] Extractable bases plus extractable acidity.

[7] Whichever of these values is higher but not to exceed 100.

[8] Dispersion quite incomplete.

[9] Contains some allophane.

[10] Contains some 2:1 lattice clay.

Chapter 5

CALCIC HORIZON

The letter designation ca is used to indicate accumulations of calcium carbonate or of calcium and magnesium carbonates. The accumulations may be in the C horizon, but they may also be found in a variety of the horizons such as mollic epipedons, argillic and natric horizons, and duripans.

The calcic horizon includes horizons of secondary carbonate enrichment that are more than 15 cm (6 inches) thick, have a calcium carbonate equivalent content of more than 15 percent, and have at least 5 percent more calcium carbonate equivalent than the C. If no C is present, and a calcic horizon is not indurated, it is more than 15 cm (6 inches) thick, has a calcium carbonate equivalent content of more than 15 percent, and contains more than 5 percent, by volume, of identifiable secondary carbonates in concretions or soft powdery forms. If a calcic horizon is indurated and rests on hard rock, or in more precise words has a lithic contact, the calcic horizon may be as thin as 2.5 cm (1 inch) if the product of the thickness in cm, multiplied by the percentage of calcium carbonate equivalent, is 200 or more (if thickness in inches is used, the product is 80 or more).

It is difficult to distinguish calcic horizons in soils from highly calcareous parent materials. Limestones are formed by precipitation of calcium carbonate or calcium and magnesium carbonates just as are ca horizons. A modern ca horizon formed on limestone is difficult to identify at present, for the only tool we can use is the measurement of the radioactive carbon (C^{14}). The measurement is expensive and can be used on relatively few soils. The most useful diagnostic feature for recognition of the calcic horizon in such situations is the presence of a surface layer that consists of fine laminae, or powdery or laminar pendants below limestone fragments. If the percentage, by volume, of powdery redeposited lime exceeds 5 percent in a layer more than 6 inches thick, or there is a laminar coating that is 2.5 cm (1 inch) or more thick, the horizon should be considered a calcic horizon.

Commonly, calcic horizons have developed in unconsolidated materials of more or less mixed mineralogic composition. In these the secondary lime is generally easy to recognize, for it occurs as a white powdery filling, as concretions, as pseudo mycelia, as pendants or crusts below pebbles and stones, or as thin sheets at lithologic discontinuities where there are breaks in the sizes of the pores. If, in such situations, the carbonate content of a layer 6 inches or more thick exceeds 15 percent by weight, and the layer has at least 5 percent more calcium carbonate equivalent than the next underlying layer, the horizon is considered a calcic horizon. Such horizons are generally thickest in gravels, other things being equal.

The genetic implications of a calcic horizon are variable. In desert regions, if the parent materials contain considerable amounts of calcium, the very limited rainfall seems unable to remove lime completely from even the surface few inches of the soil. About the only significant horizon that can develop in such a soil is a calcic horizon. Soil 59, page 162, illustrates such a situation. In areas transitional from the desert to the steppes, an A1 horizon, or mollic epipedon, may develop in addition to the calcic horizon. Apparently, no other horizons ordinarily develop. Such soils are the arid and semiarid equivalents of the Rendolls (Rendzinas) of humid regions. Given a parent material that is rich in carbonates or given regular additions of carbonates in dust, the calcic horizon tends in time to become plugged with carbonates and cemented into a hard, massive, continuous horizon that we call the petrocalcic horizon. Such horizons seem to be restricted to surfaces older than the late Pleistocene. The younger soils seem to have calcic horizons in which the lime is soft and disseminated, or has accumulated in hard concretions or both. The petrocalcic horizon is a mark of advanced soil evolution. The non-cemented calcic horizon is a mark of relatively recent development (Soil 59, page 102) or a scarcity of carbonates.

In soils that have, near the surface, ground waters that contain appreciable amounts of calcium bicarbonate, the capillary rise and evaporation, plus transpiration, cause precipitation of large amounts of lime. Depending on the height of the capillary fringe, the deposition of lime may take place in the very surface, or in the soil at depths of a foot or two. In such soils, the accumulation of lime is comparable to the accumulation of more soluble salts in the desert playas. One might think of such soils as the humid equivalents of the Salorthids (Solonchaks). Soil 1, page 66, is a soil with such a calcic horizon.

In the situation just discussed, one might attach a high genetic significance to a calcic horizon. In some other circumstances, however, one can attach no genetic significance to a calcic horizon. Deposition from ground water at depths of 10 feet or more is more nearly a geologic than a pedologic process. In soils formed from calcareous materials on the steppes, the amount of accumulation of lime may be extremely erratic, and, in fact, may vary from one foot to the next. One might consider the presence or absence of a ca horizon to be significant at some categoric level, but one might not be concerned at any categoric level with the absolute amount of accumulation that makes the distinction between a ca and a calcic horizon. Soil 3, page 68, is typical of a soil in which there is a calcic horizon of no apparent genetic or other significance. The mollic epipedon and the argillic horizon are significant to the classification of this soil. The presence of a ca horizon is also significant, but the absolute amount of lime in the ca horizon has no known significance.

Chapter 5

THE DURIPAN

The duripan is a subsurface horizon that is cemented by silica, usually opal or microcrystalline forms of silica, to the point that fragments from the air-dry horizon will not slake in water or acid. The duripans vary in the degree of cementation by silica, and in addition, often contain accessory cements, chiefly iron oxides and calcium carbonates. As a consequence, the duripans vary in appearance. They grade into the petrocalcic horizons of semiarid and arid climates, into the fragipans of humid climates, and into noncemented earthy materials.

The Genesis

Duripans occur primarily in soils of subhumid Mediterranean or arid climates--soils that are usually dry or that are seasonally dry. They have an environment in which soluble silica might be expected to be washed down into but not out of the soil.

The parent materials normally contain small amounts of calcium. Where calcium is abundant, calcic horizons tend to supplant the duripans. The most strongly expressed cementation is commonly in soils that contain appreciable amounts of glass in the overlying horizons, which suggests the importance of soluble silica to the genesis.

If glass is lacking in the overlying horizons, there is reason to suspect that it was once in the soil. Geographically, the duripans are restricted to areas of vulcanism. Ash showers may be continuing, or the soils may be in sediments worked from regions rich in pyroclastic materials such as tuffs and ignimbrites. Glass tends to weather rapidly, and if it is rich in bases, can liberate soluble silicates at a rapid rate.

Appearance of the Duripan in Arid Climates

The strongly cemented duripans of arid climates are usually platy, and the plates are roughly 1 to 15 cm thick. Pores, and the surfaces of the plates, are coated with opal and some birefringent material that is probably a microcrystalline form of silica. Carbonates are often present in small to large amounts. Roots can often be found between the plates. The cementation can be destroyed by first soaking in acid to remove any carbonates, and then by soaking in concentrated alkali. If a calcareous laminar layer similar to that of the petrocalcic horizon is present, cementation in at least half of the laminar layer is not destroyed by soaking in acid; but it is completely destroyed by concentrated alkali either as a single treatment or by alternating treatments with acid. Usually the presence of a continuous thin opal capping that is insoluble in acid on the laminar layer indicates enough silica cementation to satisfy this requirement. If no laminar layer is present and the horizon is cemented and satisfies criteria of the calcic horizon, it is a duripan if at least a continuous subhorizon within the horizon does not slake in acid. Usually, a nearly continuous layer of secondary silica occurs in this part of the horizon.

The forms transitional to regolith in arid climates are massive and brittle when wet. Silica laminar caps and silica coatings on plates may not be present. In order for the horizon to be a duripan there must be at least a few vertical opal coatings, or durinodes must make up at least 20 percent (by volume) of the horizon. In addition opal or other forms of silica partly fills interstices, and bridges sand-sized mineral grains. Moistened specimen of this form of the duripan usually show a dull glassy luster when viewed under a hand lens. These forms of the duripan are very firm or extremely firm when moist, but can be penetrated with some difficulty with an auger. Under irrigation such horizons are slowly permeable to water and virtually impenetrable to roots of many plants.

Appearance of the Duripan in Mediterranean Climates

In the forms transitional to regolith, the duripans are only weakly cemented. When the pan is moist, brittleness is pronounced, but with some difficulty, it can be penetrated by an auger. When dry, the pan is very hard. Permeability is slow. In Mediterranean climates, the pan has an abrupt upper boundary and is usually broken into very coarse prisms, or polygons, roughly 1/3 to 3 or more meters in diameter. Coatings of opal partially line the faces of the prisms and many of the pores. Roots are scarce or absent in the prisms but may be matted on the surface of the pan and on the sides of the prisms. The prisms may have been formed by volume changes that result from wetting and drying. This is suggested by the absence of prisms in the duripans of arid regions.

The more strongly cemented pans of Mediterranean climates have opal coatings over the tops of the polygons as well as the sides, and the coatings are thicker. Water often stands temporarily on top of the pans during the rainy season. Coatings of iron, manganese, and oriented clay often may be observed on these pans. Subsequent deposits of opal could engulf such coatings, and give rise to a cementation that can be broken down only by repeated alternate use of solutions of concentrated acid and alkali. Figure 37, p. 212, shows a thin section of the upper 2.5 cm of such a pan. Carbonates may be found above or in any part of the pan, or they may be completely absent, all of which indicates that carbonates are not an essential part of the pans. Figure 18, p. 55, shows a fragment of a duripan that is partially cemented with lime, but the dark surface crust is probably opal, iron, and manganese.

Loamy very fine sand
Very fine sandy loam
Silt loam
Loam
Silt

6d. Fine-silty:

With more than 18 percent clay but less than 35 percent clay, and less than 15 percent coarser than very fine sand (including coarse fragments up to 7.5 cm):

Very fine sandy loam
Silt loam
Silty clay loam
Loam
Clay loam

7. CLAYEY[1]:

7a. Fine:

With more than 35 percent clay but less than 60 percent clay:

Clay loam
Silty clay loam
Clay
Silty clay
Sandy clay

7b. Very fine:

With more than 60 percent clay.

[1] These terms refer to texture of fine earth fraction (less than 2mm) in applicable horizons that have less than 35 percent coarse fragments, by volume.

Particle-size classes, as defined, are not applied to fragipans, duripans, or petrocalcic horizons but are applied to the following horizons or to the materials that are between given arbitrary depth limits that constitute the control section:

a. lithic subgroups and shallow soils: particle-size classes are applied from the surface down to a lithic or paralithic contact, fragipan, duripan, or petrocalcic horizon, if any of these come within a depth of 36 cm (14 inches) or less or to 36 cm if the soil temperature is 0°C or less within this depth about 2 months after the summer solstice;

b. other Entisols, Inceptisols, Spodosols, Oxisols, great groups without argillic or natric horizons in Aridisols and Mollisols, and great groups with fragipans in or above argillic horizons in Alfisols and Ultisols:

(1) from a depth of 25 cm (10 inches) down to a lithic or paralithic contact, fragipan, duripan, or petrocalcic horizon, if any of these is shallower than 1 m (40 inches), or to a depth of 25 cm (10 inches) below the level at which the soil temperature is 0°C about 2 months after the summer solstice, whichever is shallower;

(2) from a depth of 25 cm (10 inches) to a depth of 1 m (40 inches) if the regolith is thicker than 1 m (40 inches) but the named diagnostic horizons and subjacent Cca horizons are not, or if the named diagnostic horizons extend below 1 m (40 inches).

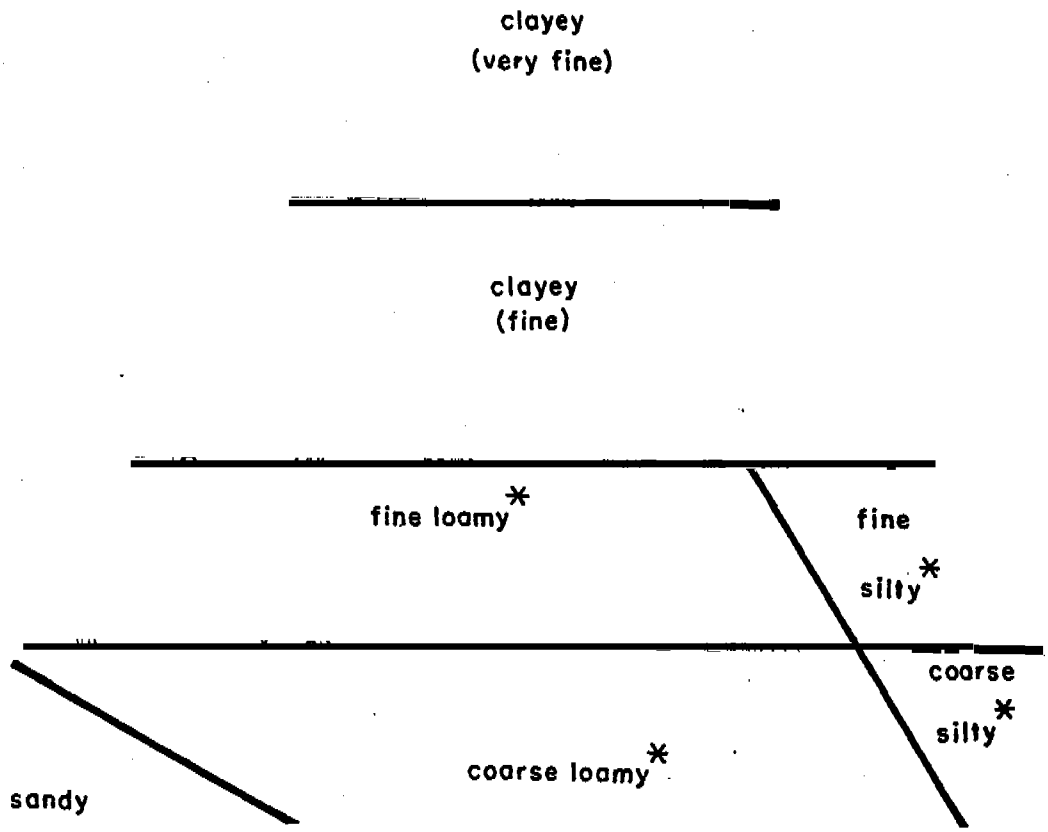
c. Other soils in Alfisols and Ultisols and great groups in Aridisols and Mollisols that have argillic or natric horizons:

(1) if there are no strongly contrasting textures or fragipan, duripan, or petrocalcic horizon between the top of the argillic or natric horizon and 1 m (40 inches), particle-size classes are applied to the whole argillic or natric horizon if less than 50 cm (20 inches) thick or to the upper 50 cm (20 inches) of the argillic or natric horizon if it is more than 50 cm (20 inches), and;

(2) if there are horizons or layers with strongly contrasting textures within or below the argillic or natric horizon and within 40 inches, particle-size classes are applied from the top of the argillic or natric horizon to 40 inches or to a lithic or paralithic contact, duripan, fragipan, or petrocalcic horizon, whichever is shallower.

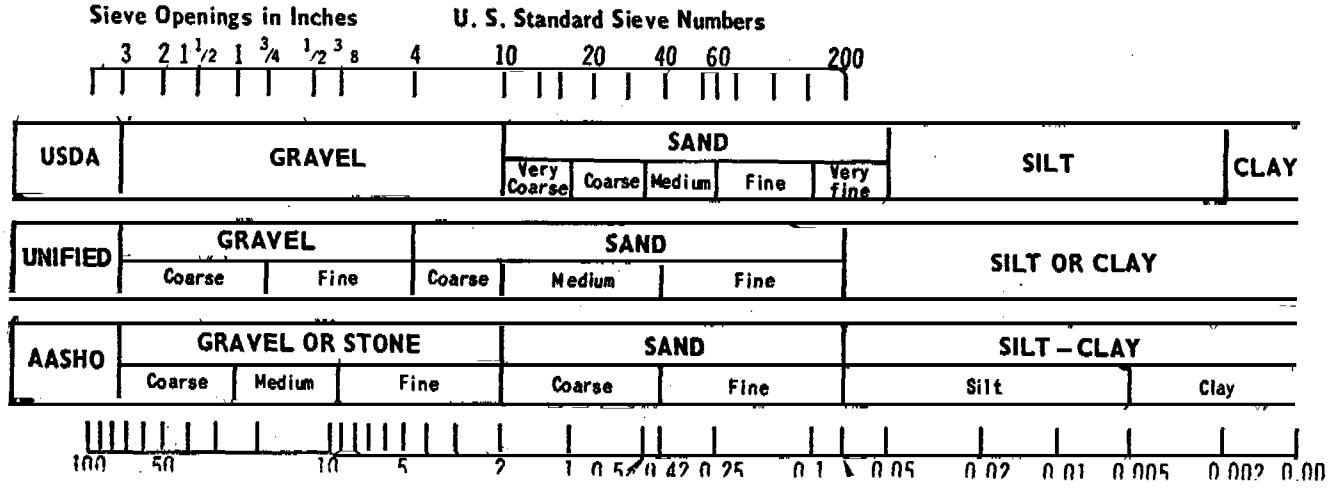
(3) if there is a fragipan, duripan, or petrocalcic horizon below an argillic or natric horizon, particle-size classes are applied from the top of the argillic horizon to the top of the fragipan, duripan, or petrocalcic horizon or to the upper 50 cm (20 inches) of the argillic or natric horizon, whichever of these is the least.

Chapter 6–3
GUIDE FOR TEXTURAL CLASSIFICATION IN SOIL FAMILIES



* Very fine sand (0.05 – 0.1) is treated as silt for family groupings; coarse fragments are considered the equivalent of coarse sand in the boundary between the silty and loamy classes.

COMPARISON OF PARTICLE SIZE SCALES



Thixotropy cont.

literature of soils of western United States, particularly of Hawaii, the consistence term "smeary" is used to characterize soil materials that are thixotropic.

Soils in which more than 1/3 of the clay fraction consists of carbonates are also placed on the basis of their apparent texture. If the apparent texture is fine-loamy, fine-silty, or clayey the term fine-carbonatic is used in place of the textural class name.

Two particle-size classes are used to separate families in Vertisols, fine if there is less than 60 percent clay and very fine if there is more than 60 percent clay in the weighted average of the control section.

2. Mineralogy: Mineralogy classes are based on the approximate mineralogical composition of selected size fractions of the same segment of the soil profile (control section) that is used for application of particle-size classes. No contrasting mineralogy families are recognized except where there is an ash or cinder overlay or an upper thixotropic layer and the ash or cinders or thixotropic layer extend at least 10 cm into the upper control section. In identifying and naming contrasting mineralogy families the 7 family particle-size classes are used for the lower part of the section. For example, ashy over loamy mixed, not ashy over coarse-loamy mixed. Otherwise, if there are contrasting particle-size classes in the control section the mineralogy of the upper part of the control section is definitive of the family mineralogy.

Mineral soils are placed in the first mineralogy class of the Key that accomodates them although they may appear to meet the requirements of other mineralogy classes. This is a Key, not a set of complete definitions. Mineralogy subclasses based on combined texture, consistence, and mineralogy classes are used to indicate important variations in Andaquepts, Andepts, and Andic subgroups.

It is recognized that it is normally impossible to be certain of the percentages of the various kinds of clay minerals. Quantitative identification methods are still lacking. Although much progress has been made in the past few decades, an element of judgment enters into the estimation. Not all of the evidence must come from X-ray, surface, and DTA determinations. Other physical and chemical properties suggest the mineralogy of many clayey soils. Volume changes, cation exchange capacities and consistence also are useful in estimating the nature of the clay. Determination of the clay mineralogy of clayey soils is based on the weighted average of the control section.

3. Reaction classes: Two classes, acid and nonacid, will be used in selected taxa, with definitions as follows:

a. Acid: pH less than 5.5 in H_2O (1:1) in control section (throughout).

b. Nonacid: pH 5.5 or more in at least some part of the control section.

Reaction classes are not to be used in sandy, sandy skeletal or fragmental families, but are to be used in other families in the following taxa:

Entisols	Humaquepts
Haplaquepts	Andaquepts

Thus, we have the following combinations reflecting the pH in the control section, and the presence or absence of carbonates, in all parts of the fine earth between 25 and 50 cm (10-20 inches) below the surface.

Psamments and Psammaquents	No reaction classes.
Other Entisols and Aquepts, except Fragiaquepts	Acid, nonacid, and calcareous classes. (Note that "calcareous" implies "nonacid", and that both names are not needed for calcareous families.)
Aquolls	Calcareous and noncalcareous classes.

Chapter 6

KEY TO MINEROLOGY CLASSES

Class	Definition	Determinant size fraction
Classes applied to loamy, silty, and clayey soils.		
Ferritic	More than 40 percent (weight) iron oxide extractable by citrate-dithionite, reported as Fe_2O_3 (or 28 percent reported as Fe).	Whole soil < 2 mm
Gibbsitic	More than 40 percent (weight) hydrated aluminum oxides reported as gibbsite and boehmite.	Whole soil < 2 mm
Oxidic	Less than 90 percent quartz and less than 40 percent of any other single mineral and the ratio of $\frac{\%\ \text{extractable iron oxide and gibbsite}}{\%\ \text{clay}\ 1/} \geq 0.20$	For iron and clay ratio: whole soil < 2 mm For quartz & other minerals: 0.002 - 2 mm
Fine-carbonatic	More than 1/3 of the < 0.002 mm fraction consists of carbonates and the apparent texture of the soil is fine-loamy or fine-silty or clayey. Particle size classes are not used with this mineralogy.	< 0.002 mm
Serpentinitic	More than 40 percent (weight) serpentine minerals (antigorite, chrysotile, fibrolite and talc).	Whole soil < 2 mm
Classes applied to sandy, silty, and loamy soils.		
Glauconitic	More than 40 percent (weight) of glauconite.	Whole soil < 2 mm
Carbonatic	More than 40 percent (weight) carbonates (as $CaCO_3$) and gypsum, and carbonates are more than 65 percent of the sum of carbonates and gypsum.	Whole soil smaller than 2 mm, or whole soil smaller than 20 mm
Gypsic	Gypsum is more than 35 percent of the sum of carbonates and gypsum, and carbonates and gypsum are more than 40 percent by weight.	Whole soil smaller than 2 mm, or whole soil smaller than 20 mm
Ashy	More than 60 percent (weight 2/) volcanic ash, cinders or pumice, and dominantly smaller than 2 mm.	0.02 - 20 mm
Cindery	Cindery if dominantly larger than 2 mm.	0.02 - 20 mm
Micaceous	More than 40 percent (weight 2/) mica.	0.02 - 20 mm
Siliceous	More than 90 percent (weight 2/) of silica minerals (quartz, chalcedony, opal) and other minerals with hardness of 7 or more in the Mohs scale.	0.02 - 2 mm
Mixed	All others, with less than 40 percent of any one mineral other than quartz.	
Classes applied to clayey soils.		
Halloysitic	More than half by weight of halloysite with smaller amounts of allophane or kaolinite or both.	< 0.002 mm
Kaolinitic	More than half by weight of kaolinite, dickite and nacrite, and with smaller amounts of other 1:1 or nonexpanding 2:1 layer minerals or gibbsite.	< 0.002 mm
Montmorillonitic	More than half by weight of montmorillonite and nontronite, or a mixture with more montmorillonite than any other single clay mineral.	< 0.002 mm
Illitic	More than half by weight of illite (hydrous mica) commonly with > 3 percent K_2O.	< 0.002 mm
Vermiculitic	More than half by weight of vermiculite or more vermiculite than any other single clay mineral.	< 0.002 mm
Mixed	Other soils.*	< 0.002 mm

1/ Or 2.5 x 15-bar water whichever is larger.
2/ Weight percentages as estimated from grain counts; usually, a count of one or two dominant size fractions of conventional mechanical analysis is sufficient for the placement of the soil.

Mineralogy subclasses

Mineralogy subclasses are used in addition to mineralogy classes in some groups of soils.

Sulfureous (Tentative)	Soils containing either iron sulfates, commonly jarosite (straw-colored), if the pH after oxidation is less than 3.5; or more than 0.75 percent sulfur in the form of polysulfides if the soil contains less than three times as much carbonate (as $CaCO_3$ equiv.) as sulfur (less than Ca^{++} than $SO_4^{=}$ if all sulfur is oxidized).	Whole soil < 2 mm Histosols and Aquents only
Calcareous	Continuous presence of free carbonates in all parts of the fine earth fraction between depth of 25 cm and 50 cm (10 and 20 inch inches). (Use in Aquepts other than Fragiaquepts, in Aquolls, and in Entisols other than Psamments and Psammaquents.)	Whole soil < 2 mm

* Sepiolitic, more than half by weight of sepiolite, attapulgite and palygorskite, should be used if found in soils that are not fine-carbonatic.

Other characteristics--Cont.

(2) Many calcic horizons are weakly cemented or even indurated. The petrocalcic horizon is expected to meet most if not all of the needs for recognition of cementation in these horizons. No cemented taxa are to be used in the family category.

d. Moisture equivalent: Despite the emphasis given texture in the classification, there is remaining variability in the sandy soils, the sands, and the loamy sands. Some sands are very clean, almost completely free of silt and clay. Others have appreciable amounts. A moisture equivalent value of 2 percent seems to make a reasonable division of the sands that is appropriate at the family level. Two classes are to be recognized as follows in Quartzipsamments:

(1) coated: With a moisture equivalent of 2 percent or more

(2) uncoated: With a moisture equivalent of < 2 percent.

With additional study it is hoped that it will be possible to develop definitions that can be applied in the field. The moisture equivalent value used is the average of the control section, weighted for thickness. Moisture retained at one-tenth bar suction may be substituted for moisture equivalent.

e. Slope, or shape of soil: Soils of aquic great groups normally have level plane, or concave surfaces, in places where the ground water saturates the soil during some season of the year. A few, however, are found on the sides of slopes where water cannot stand, and are kept wet by more or less continuous seepage of water from higher lying areas. In a very few, hydrostatic pressures keep the soils wet. No consistent internal morphologic clues have yet been found that distinguish these situations, but the recognition in the field from the position of the soil in the landscape is generally easy. It is proposed therefore in aquic great groups, particularly in Aquolls and Aquults, to use the shape of the soil as a family differentia. Classes of level and sloping seem adequate, with these defined as they are in the Soil Survey Manual. It may be necessary to use slope classes in other orders, but they should not be used in families of Aquods or Albaqualfs.

FAMILY NAMES

Each family will require one or more names. One family name consists of a series of adjectives modifying the subgroup name. For these adjectives we take the class names given for texture, mineralogy, and so on, in family differentiae. To have consistent nomenclature, the order of adjectives is the texture, mineralogy class and subclass, reaction, temperature, permeability, depth, slope, consistence, and coatings.

The other family name is the name of one of the series in the family. This name is underscored in the lists of series in each family. This is a shorter name intended primarily for use in conversations. This short name is most useful if the series is a common one that is well known in the locality. It may develop that some families will acquire several such names in different parts of the country, according to the series in the family that is best known locally.

CONTROL SECTION FOR SOIL SERIES

Primary attention at the series level is given to a control section. Many classes of soil within higher categories of the system have already been set apart on the basis of soil characteristics both within and without this control section. For the control section, attention is centered on genetic horizons if they are well expressed and not thin. If the genetic horizons are not well expressed or are thin, attention is centered on a corresponding portion of the regolith. Differences in soil or regolith outside the control section and not differentiae in categories higher than the series but relevant to the usefulness of the soils are bases for phase distinctions.

Whether or not there are well expressed genetic horizons, the portion of the soil to be considered in differentiating series within a family of mineral soils is as follows:

Cryic soils. From the mineral surface to a depth of 30 inches, or to a lithic or paralithic contact, or to a depth 10 inches below the level at which the soil temperature is 0°C about two months after the summer solstice, whichever is shallower.

Very shallow soils. From the mineral surface down to a lithic or paralithic contact if thickness of regolith is 14 inches or less.

All other mineral soils. (Orders 1 through 9). From a depth of 10 inches down to (1) a lithic contact if it is within a depth of 40 inches, (2) a depth of 40 inches if the regolith is thicker than that but the named diagnostic horizons and subjacent Cca horizons are not, or (3) the bottom of the named diagnostic horizons and any subjacent Cca horizon if the thickness of both the named diagnostic horizons and the regolith exceeds 40 inches (about one meter), but not below a depth of 80 inches (roughly 2 meters).* (Note that calcic and gypsic horizons and duripans are diagnostic only if their upper boundaries are within 1 meter. Salic horizons are diagnostic if they start within 30 inches (or 75 cm) of the soil surface).

* A lower depth of 2 meters is tentative. The depth for the control section in grossarenic subgroups is still under discussion at the time of this printing.

CHAPTER 7

KEY TO ORDERS, SUBORDERS, AND GREAT GROUPS*

A. Mineral soils without a lithic or paralithic contact within 50 cm (20 inches) of the soil surface that have:

1. After the upper 18 cm (7 inches) are mixed, 30 percent or more clay in all horizons down to a lithic or a paralithic contact, or to a calcic horizon, or to 1 m (40 inches), whichever is shallower;

2. At some period in most years, cracks at least 1 cm wide at a depth of 50 cm (20 inches);

3. One or more of the following:

   a. Gilgai;
   b. At some depth between 25 cm and 1 m (10 and 40 inches), slickensides close enough to intersect;
   c. At some depth between 25 cm and 1 m (10 and 40 inches), wedge-shaped or parallelepiped natural structural aggregates with their long axes tilted 10 to 60 degrees from horizontal.

ORDER 2 - Vertisols, p. 86

AA. Vertisols that are usually dry in all parts and have cracks that remain open throughout the year in most years. If inundated, the cracks may close for variable periods; if cultivated, the cracks may extend upwards only to the lower boundary of the Ap horizon.

Torrerts, p. 86

AB. Other Vertisols that have cracks that remain open for 90 cumulative days or more but not throughout the year in most years, and one or more of the following:

1. Cracks that open and close more than once during the year in most years;

2. A mean annual soil temperature of 22°C (72°F) or more;

3. Mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by less than 5°C (9°F).

Usterts, p. 87

ABA. Usterts that have moist chromas of less than 1.5 throughout the upper 30 cm (12 inches).

Pellusterts, p. 87

ABB. Other Usterts.

Chromusterts, p. 87

AC. Other Vertisols that have cracks that open and close once each year and remain open for 60 consecutive days or more during the year in more than 7 out of 10 years.

Xererts, p. 88

ACA. Xererts that have moist chromas of less than 1.5 throughout the upper 30 cm (12 inches).

Pelloxererts, p. 88

ACB. Other Xererts.

Chromoxererts, p. 88

AD. Other Vertisols that are usually moist in some part during most years and have cracks that open and close one or more times during the year but do not remain open for as many as 90 cumulative days; in a few years the soils may not crack.

Uderts, p. 86

ADA. Uderts that have moist chromas of less than 1.5 throughout the upper 30 cm (12 inches).

Pelluderts, p. 86

ADB. Other Uderts.

Chromuderts, p. 86

* Throughout the Key, unless specified otherwise, it is assumed that the soils are under natural conditions, that is, not irrigated and not artificially drained. The indicated moisture status refers to the period of the year when the soil is not frozen in any part. For example, if a soil is frozen in some part for 90 days, then the soil will be usually moist if it is moist in some part (but not necessarily the same part) between 18 cm and 50 cm(7 and 20 inches) depth for more than one-half of

KEY

B. Other mineral soils that have no diagnostic horizon other than an ochric or an anthropic epipedon, an albic or an agric horizon, with or without any of the following:

1. A salic horizon, except that if the soil is saturated within 1 m (40 inches) for 1 month or more, and has not been irrigated, the upper boundary of the salic horizon must be 75 cm (30 inches) or more below the surface.

2. If textures are finer than loamy fine sand, sodium saturation may exceed 15 percent in some part of the upper 50 cm (20 inches) only if sodium saturation increases or remains constant with depth below 50 cm (20 inches) and the soil is saturated with water within 1 m (40 inches) of the surface for 1 month or more when not frozen in any part;

3. A calcic or gypsic horizon or duripan if its upper boundary is deeper than 1 m (40 inches) below the surface;

4. Plinthite that forms a continuous phase if the upper boundary is deeper than 1.25 m (50 inches) below the surface;

5. Buried diagnostic horizons other than a buried ochric epipedon if the surface of the buried solum is deeper than 50 cm (20 inches) or is at depths between 30 and 50 cm (12 and 20 inches) and the thickness of the buried solum is less than twice the thickness of the overlying deposits;

6. Ironstone at any depth;

7. If textures are coarser than loamy very fine sand to a depth of 1 m (40 inches), plinthite in the form of discrete nodules or disconnected, soft, red mottles if it constitutes less than half of the volume in all subhorizons.

ORDER 1 - Entisols, p. 70

BA. Entisols that are either 1. permanently saturated with water and have dominant hues in all horizons below 25 cm (10 inches) that are (1) bluer than 10Y and (2) that change on exposure to the air; or 2. that are saturated with water at some period of the year or are artificially drained and that have, within 50 cm (20 inches) of the surface, dominant moist colors in the matrix as follows:

1. In horizons with textures finer than loamy fine sand

   a. If there is mottling, chromas are 2 or less

   b. If there is no mottling and values are less than 4, chromas are less than 1; if values are 4 or more, chromas are 1 or less

2. In horizons with textures of loamy fine sand or coarser

   a. If hues are as red or redder than 10YR and there is mottling, chromas are 2 or less; if there is no mottling and values are less than 4, chromas are less than 1 or if values are 4 or more, chromas are 1 or less;

   b. If hues are between 10YR and 10Y and there is distinct or prominent mottling, chromas are 3 or less; if there is no mottling, chromas are 1 or less;

   c. Hues are bluer than 10Y;

   d. Any color if the color is due to uncoated grains of sand.

Aquents, p. 70

BAA. Aquents that have an N value of more than 0.5 and at least 8 percent clay and 3 percent organic matter in all subhorizons between 20 and 50 cm (8 and 20 inches), and mean annual soil temperatures more than 0°C (32°F).

Hydraquents, p. 72

BAB. Other Aquents that have a mean annual soil temperature of less than 8°C (47°F) and have a mean summer soil temperature at 50 cm (20 inches) of less than 15°C (59°F) if they are drained and lack an O horizon or are cultivated; or if they are drained and have an O horizon, have a mean summer temperature at 50 cm (20 inches) of less than 8°C (47°F); or if they are undrained and have an O horizon, have a mean summer temperature of less than 6°C (43°F).

Cryaquents, p. 70

KEY

BAC. Other Aquents that have less than 5°C (9°F) difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches).

Tropaquents, p. 72

BAD. Other Aquents that have textures of loamy fine sand or coarser in all horizons below the Ap horizon or 25 cm (10 inches), whichever is deeper, to a depth of 1 m (40 inches) or to a lithic or paralithic contact, whichever is shallower, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more.

Psammaquents, p. 72

BAE. Other Aquents.

Haplaquents, p. 71

BB. Other Entisols that have below the Ap horizon or 25 cm (10 inches), whichever is deeper, textures of loamy fine sand or coarser in all parts either to a depth of 1 m (40 inches) or to a lithic or a paralithic contact, whichever is shallower; and that have no identifiable fragments of diagnostic horizons without discernible order within the series control section.

Psamments, p. 82

BBA. Psamments that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of either less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon.

Cryopsamments, p. 82

BBB. Other Psamments that have in the sand fraction more than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or aluminum.

Quartzipsamments, p. 82

BBC. Other Psamments that are usually dry in most years in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or paralithic, whichever is shallower, or in some subhorizon above a lithic or paralithic contact shallower than 18 cm (7 inches).

Torripsamments, p. 83

BBD. Other Psamments that are dry for 90 cumulative days or more in most years in some subhorizon(s) between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, but are not continuously dry in all parts of the soil between these depths or in the subhorizon immediately above a lithic or paralithic contact shallower than 18 cm for as long as 60 consecutive days in more than 7 out of 10 years unless either the mean annual soil temperature is 22°C (72°F) or higher or the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by less than 5°C (9°F), or both.

Ustipsamments, p. 84

BBE. Other Psamments that are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 cm (7 inches), whichever is deeper, and 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, or in the subhorizon immediately above a lithic or paralithic contact shallower than 18 cm (7 inches).

Xeropsamments, p. 84

BBF. Other Psamments.

Udipsamments, p. 83

BC. Other Entisols that lack fragments of diagnostic horizons that can be identified and have slopes of less than 25 percent and organic matter content that decreases irregularly with depth or remains above levels of 0.35 percent (0.2 percent carbon) for 1.25 m (50 inches); the mean annual soil temperature is more than 0°C (32°F). (Thin strata of sand or loamy sand may have less organic matter if the finer sediments at 1.25 m (50 inches) or below have 0.2 percent carbon or more.)

Fluvents, p. 73

BCA. Fluvents that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at a depth of 50 cm (20 inches) of either less than 15°C (59°F) if cultivated or without an O horizon, or less less than 8°C (47°F) if with an O horizon.

Cryofluvents, p. 73

KEY

CA. Inceptisols that either are saturated with water at some period of the year or artificially drained, and that have, at depths of less than 50 cm (20 inches), characteristics associated with wetness, namely, one or more of the following:

1. A histic epipedon;
2. Sodium saturation of more than 15 percent in some part of the upper 50 cm (20 inches) that decreases with depth below 50 cm (20 inches);
3. Dominant moist colors on ped faces, or in the matrix if peds are absent, as follows:
   a. If there is mottling within the horizon, chromas are 2 or less;
   b. If there is no mottling, chromas are 1 or less.*

Aquepts, p. 92

CAA. Aquepts that have a mean annual soil temperature of less than 8°C (47°F) and have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of less than 15°C (59°F) if they are drained and either cultivated or lack an O horizon; of less than 8°C (47°F) if they are drained and have an O horizon or a histic epipedon; and less than 6°C (43°F) if they are undrained and have an O horizon or a histic epipedon. N values are 0.5 or less in some horizon between 20 and 50 cm (8 and 20 inches) or the mean annual soil temperature is 0°C (32°F) or less.

Cryaquepts, p. 92

CAB. Other Aquepts that have plinthite that forms a continuous phase or constitutes more than half of the matrix within some subhorizon in the upper 1.25 m (50 inches) of the soil.

Plinthaquepts, p. 97

CAC. Other Aquepts that have a bulk density of the fine earth fraction of the soil of less than 0.85 g per cc in some horizon; no fragipan; and an exchange complex that is dominated by amorphous materials; or vitric volcanic ash, cinders, or other vitric pyroclastic materials constitute 60 percent or more of the silt, sand, and gravel fractions.

Andaquepts, p. 92

CAD. Other Aquepts that have less than 5°C (9°F) difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches), or at a lithic or paralithic contact, whichever is shallower.

Tropaquepts, p. 97

CAE. Other Aquepts that have a fragipan.

Fragiaquepts, p. 93

CAF. Other Aquepts that have sodium saturation that is more than 15 percent in some part of the upper 50 cm (20 inches) and that decreases with depth below 50 cm (20 inches).

Halaquepts, p. 94

CAG. Other Aquepts that have an umbric, a mollic, or a histic epipedon.

Humaquepts, p. 96

CAH. Other Aquepts that have an ochric epipedon.

Haplaquepts, p. 94

* If hues are redder than 10 YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived.

CB. Other Inceptisols that have a plaggen epipedon.

Plaggepts, p. 103

CC. Other Inceptisols that have one or both of:

1. A bulk density of the fine earth fraction of the soil of less than 0.85 g per cc in the epipedon or the cambic horizon or both and an exchange complex that is dominated by amorphous material;
2. Have 60 percent or more of vitric volcanic ash, cinders, or other vitric pyroclastic material in the silt, sand, and gravel fractions.

Andepts, p. 89

CCA. Andepts that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon, or of less than 8°C (47°F) if with an O horizon.

Cryandepts, p. 90

CCB. Other Andepts that have a duripan within 1 m (40 inches) of the surface.

Durandepts, p. 90

CCC. Other Andepts that have clays that dehydrate irreversibly into gravel-size aggregates.

Hydrandepts, p. 91

CCD. Other Andepts that have a mollic epipedon; and are thixotropic in some horizon or the 15-bar water is 20 percent or more based on the average for the whole soil in the control section.

Eutrandepts, p. 90

CCE. Other Andepts that have an umbric or ochric epipedon; and are thixotropic in some horizon or the 15-bar water is 20 percent or more based on the whole soil in the control section.

Dystrandepts, p. 90

CCF. Other Andepts.

Vitrandepts, p. 91

CD. Other Inceptisols that have a mean annual soil temperature of 8°C (47°F) or more and have less than 5°C (9°F) difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, and one of:

1. An umbric epipedon;
2. A mollic epipedon with one or both of the following:
   a. 35 percent or more clay with montmorillonitic mineralogy, and the epipedon rests on materials with less than 40 percent $CaCO_3$ equivalent;
   b. a cambic horizon with base saturation that is less than 50 percent (by NH_4OAc) throughout or decreasing to less than 50 percent at a depth of 1.8m (72 inches).
3. An ochric epipedon and a cambic horizon.

Tropepts, p. 103

CDA. Tropepts that have 50 percent or more base saturation (by NH_4OAc) throughout the epipedon and any cambic horizon, and either are dry in some horizon for 90 cumulative days or more in most years or have a horizon containing soft, powdery secondary lime within 1.5m(60 inches) of the surface.

Ustropepts, p. 106

KEY

CDB. Other Tropepts with 50 percent or more base saturation (by NH_4OAc) throughout the epipedon and any cambic horizon.

Eutropepts, p. 104

CDC. Other Tropepts with a mean annual soil temperature of 22°C (72°F) or more.

Dystropepts, p. 104

CDD. Other Tropepts.

Humitropepts, p. 105

CE. Other Inceptisols that have one of the following characteristics:

1. If the mean annual soil temperature is 8°C (47°F) or more, either an umbric or anthropic epipedon that is more than 25 cm (10 inches) thick or a mollic epipedon that is more than 25 cm (10 inches) thick if it is underlain by a cambic horizon with base saturation of less than 50 percent (by NH_4OAc) in some part;
2. If the mean annual soil temperature is less than 8°C (47°F), either an umbric or a mollic epipedon if the mollic epipedon is underlain by a cambic horizon that has base saturation of less than 50 percent (by NH_4OAc) in some part.

Umbrepts, p. 107

CEA. Umbrepts that have an anthropic epipedon.

Anthrumbrepts, p. 107

CEB. Other Umbrepts that have a fragipan.

Fragiumbrepts, p. 108

CEC. Other Umbrepts that have a mean annual soil temperature of less than 8°C (47°F) and have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon.

Cryumbrepts, p. 107

CED. Other Umbrepts that are never dry, or are not dry for as much as 60 consecutive days in more than 7 out of 10 years in all subhorizons between 18 cm and 50 cm (7 and 20 inches) or a lithic or paralithic contact, whichever is shallower, or in the subhorizon immediately above a lithic or paralithic contact shallower than 18 cm (7 inches).

Haplumbrepts, p. 108

CEE. Other Umbrepts.

Xerumbrepts, p. 109

CF. Other Inceptisols.

Ochrepts, p. 98

CFA. Ochrepts that have a fragipan.

Fragiochrepts, p. 101

CFB. Other Ochrepts that have a duripan with its upper boundary within 1 m (40 inches) of the surface.

Durochrepts, p. 98

CFC. Other Ochrepts that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon.

Cryochrepts, p. 98

KEY

CFD. Other Ochrepts that are dry for 90 cumulative days or more in most years in some subhorizon(s) of the soil between 18 cm and 50 cm (7 and 20 inches) depth or above a lithic or a paralithic contact shallower than 50 cm (20 inches) but are not continuously dry in all parts of the soil between these depths for as long as 60 consecutive days in more than 7 out of 10 years unless the mean annual soil temperature is 22°C (72°F) or higher, or the mean summer and mean winter soil temperatures at 50 cm depth differ by less than 5°C (9°F) or both.

Ustochrepts, p. 101

CFE. Other Ochrepts that are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 cm and 50 cm (7 and 20 inches) or a lithic or a paralithic contact, whichever is shallower, or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches).

Xerochrepts, p. 102

CFF. Other Ochrepts that have one or both of:

1. Carbonates in the cambic horizon or in the C horizon but within the soil;
2. Base saturation (by NH_4OAc) that is 60 percent or more in some subhorizon that is within 75 cm (30 inches) of the soil surface.

Eutrochrepts, p. 100

CFG. Other Ochrepts.

Dystrochrepts, p. 99

D. Other mineral soils that have an ochric epipedon but have no oxic or spodic horizon and one or more of the following combinations of properties:

1. No argillic or natric horizon but within 1 m (40 inches) of the surface have one or more of the following horizons: calcic, petrocalcic, gypsic, cambic, or duripan; and either are usually dry between 18 cm and 50 cm (7 and 20 inches) depth or a lithic or a paralithic contact, whichever is shallower or have a conductivity of the saturation extract that is 2 mmho per cm or greater at 25°C in some part above whichever of the following depths is least: a lithic or paralithic contact, 1.25 m (50 inches) if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey; or with increase in depth within the C horizon but above the depths for the different particle-size classes specified above there is an increase in saturation with Na plus K in some part;
2. No argillic or natric horizon but have a salic horizon within 75 cm (30 inches) of the surface and are saturated with water within 1 m (40 inches) of the surface for one month or more;
3. A surface horizon that is not both hard and massive when dry; and argillic or natric horizon; and usually dry in most years in all parts of the soil between 18 cm and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in some subhorizon above a lithic or a paralithic contact shallower than 18 cm (7 inches).

ORDER 4 - Aridisols, p. 110

DA. Aridisols that lack an argillic or natric horizon unless it is a buried horizon.

Orthids, p. 115

DAA. Orthids that have a duripan with its upper boundary within 1 m (40 inches) of the surface.

Durorthids, p. 118

DAB. Other Orthids that:

1. Have a salic horizon within 75 cm (30 inches) of the surface if saturated with water (i.e. within the capillary fringe) within 1 m (40 inches) of the surface for 1 month or more; and
2. Lack a calcic or gypsic horizon above the salic horizon.

Salorthids, p. 120

DAC. Other Orthids that have a petrocalcic horizon with its upper boundary within 1 m (40 inches) of the soil surface.

Paleorthids, p. 119

KEY

EAA. Aquods that have a fragipan below the spodic horizon but that lack a placic horizon above the fragipan.

Fragiaquods, p. 152

EAB. Other Aquods that have no placic horizon but have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of:

1. Less than 15°C (59°F) if they are drained and lack an O horizon;
2. Less than 8°C (47°F) if they are drained and have an O horizon;
3. Less than 6°C (43°F) if they are undrained and have an O horizon or a histic epipedon.

Cryaquods, p. 151

EAC. Other Aquods that have a strongly cemented or indurated albic horizon that will not slake in water when a dry fragment is immersed.

Duraquods, p. 151

EAD. Other Aquods that have a placic horizon that rests on a spodic horizon, a fragipan, or an albic horizon that is underlain by a fragipan.

Placaquods, p. 153

EAE. Other Aquods that have a mean annual soil temperature of 8°C (47°F) or higher and mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by less than 5°C (9°F).

Tropaquods, p. 154

EAF. Other Aquods that have one or both of:

1. In more than 50 percent of each pedon, a spodic horizon with some subhorizon that contains dispersed organic matter and aluminum and lacks sufficient free iron to turn redder on ignition (less than 0.5 percent in the fine earth fraction expressed as Fe);
2. An Ap horizon that has a moist value of 3 or less and a moist chroma of 2 or less and that rests directly on a spodic horizon having in its upper part a subhorizon or some tongues with one or both of:
   a. Dispersed organic matter and a moist value and moist chroma of 3 or less;
   b. Less than 0.7 percent free iron expressed as Fe.

Haplaquods, p. 152

EAG. Other Aquods.

Sideraquods, p. 153

EB. Other Spodosols that have one or both of:

1. In more than 50 percent of each pedon a spodic horizon with a subhorizon that contains dispersed organic matter and aluminum and that lacks sufficient free iron to turn redder on ignition (less than 0.5 percent in the fine earth fraction expressed as Fe);
2. An Ap horizon with a moist value of 3 or less and a moist chroma of 2 or less and rests directly on a spodic horizon that has in its upper part a subhorizon or some tongues possessing one or both of:
   a. Dispersed organic matter and a value and chroma of 3 or less when moist;
   b. Less than 0.7 percent free iron expressed as Fe.

Humods, p. 155

EBA. Humods that have a placic horizon in the spodic horizon.

Placohumods, p. 156

EBB. Other Humods that have a mean annual soil temperature of 8°C (47°F) or higher and mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Tropohumods, p. 156

KEY

EBC. Other Humods that have a fragipan below the spodic horizon.

Fragihumods, p. 155

EBD. Other Humods that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) either less than 15°C (59°F) if cultivated or without an O horizon or less than 8°C (47°F) if with an O horizon.

Cryohumods, p. 155

EBE. Other Humods.

Haplohumods, p. 155

EC. Other Spodosols that have a spodic horizon that has in some subhorizon a ratio of free iron (elemental) to carbon of 6 or less.

Orthods, p. 156

ECA. Orthods that have a placic horizon above or in the spodic horizon.

Placorthods, p. 159

ECB. Other Orthods that have a fragipan below the spodic horizon.

Fragiorthods, p. 157

ECC. Other Orthods that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon; or less than 8°C (47°F) if with an O horizon.

Cryorthods, p. 156

ECD. Other Orthods.

Haplorthods, p. 158

ED. Other Spodosols.

Ferrods, p. 154

F. Other mineral soils that have a mean annual soil temperature of 8°C (47°F) or higher;and if mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, differ by 5°C (9°F) or more,have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of 15°C (59°F) or higher if without an O horizon or 8°C (47°F) or higher if with an O horizon; no oxic horizon unless it underlies an argillic horizon; no plinthite that forms a continuous phase within 30 cm (12 inches) of the soil surface; and one of the following combinations of characteristics:

1. No fragipan and base saturation (by sum of cations) of less than 35 percent at 1.25 m (50 inches) below the upper boundary of the argillic horizon or 1.8 m (72 inches) below the soil surface or above a lithic or a paralithic contact, whichever is shallower;

2. A fragipan that:

   a. Meets all of the requirements of an argillic horizon or that has clay skins 1 mm or more thick in some part;

   b. Has base saturation (by sum of cations) of less than 35 percent at a depth of 75 cm (30 inches) below the upper boundary of the fragipan.

ORDER 8 - Ultisols, p. 184

FA. Ultisols, either saturated with water at some period or artificially drained, that have characteristics associated with wetness, namely: mottles, iron-manganese concretions > 2 mm or has moist chromas of 2 or less immediately below any Ap or A1 horizon that has moist values of less than 3.5 when rubbed, and one of the following:

1. Dominant moist chromas of 2 or less in coatings on the surface of peds accompanied by mottles within the peds, or dominant chromas of 2 or less in the matrix of the argillic horizon accompanied by mottles of higher chromas (if hues are redder than 10YR because of parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived);

KEY

FBE. Other Ustults.

Haplustults, p. 194

FC. Other Ultisols that:

1. Are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 cm and 50 cm (7 and 20 inches) or a lithic or a paralithic contact, whichever is shallower;
2. Have less than 1.5 percent organic matter (0.87 percent carbon) in the upper 15 cm (6 inches) of the argillic horizon exclusive of any Ap;
3. Have less than 20 kg organic matter in a unit volume of 1 m^2 to a depth of 1 m (40 inches) below the base of any O horizon or the mineral surface.

Xerults, p. 196

FCA. Xerults that have an argillic horizon that has less than 10 percent weatherable minerals in the 20 to 200 micron fraction in the upper 1 m (40 inches) and has a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletans or other evidences of clay eluviation.

Palexerults, p. 197

FCB. Other Xerults.

Haploxerults, p. 197

FD. Other Ultisols that either:

1. Have 1.5 percent or more organic matter (0.87 percent carbon) in the upper 15 cm (6 inches) of the argillic horizon;
2. Have 20 kg or more organic matter in a unit volume of 1 m^2 to a depth of 1 m (40 inches) below the base of any O horizon or both.

Humults, p. 186

FDA. Humults that have an argillic horizon that has less than 10 percent weatherable minerals in the 20 to 200 micron fraction in the upper 1 m (40 inches) and has a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletans or other evidences of clay eluviation.

Palehumults, p. 187

FDB. Other humults that have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Tropohumults, p. 188

FDC. Other Humults.

Haplohumults, p. 186

FE. Other Ultisols.

Udults, p. 188

FEA. Udults that have a fragipan in or below the argillic horizon.

Fragiudults, p. 189

FEB. Other Udults that have plinthite that forms a continuous phase or constitutes more than half of the volume in some horizon within the upper 1.25 m (50 inches) of the soil.

Plinthudults, p. 192

FEC. Other Udults that have an argillic horizon that has less than 10 percent weatherable minerals in the 20 to 200 micron fraction in the upper 1 m (40 inches) and has a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletans or other evidences of clay eluviation.

Paleudults, p. 191

KEY

FED. Other Udults that have:

1. An epipedon with moist color values of less than 4 in all parts;
2. An argillic horizon with dry color values of less than 5 and no more than 1 unit higher than moist values.

Rhodudults, p. 192

FEE. Other Udults that have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Tropudults, p.193

FEF. Other Udults.

Hapludults, p. 190

G. Other mineral soils that lack an oxic horizon and that either have a mollic* epipedon or have a surface horizon that, after mixing to 18 cm (7 inches) meets all requirements for a mollic epipedon except thickness and in addition have an upper subhorizon in an argillic or natric horizon that is more than 7.5 cm (3 inches) thick, and that meets the color, organic matter, base saturation, and structure requirements of a mollic epipedon, but that is separated from the surface horizon by an albic horizon. (Note that the combined thicknesses meet the thickness requirement for a mollic epipedon.)

ORDER 5 - Mollisols, p. 121

GA. Mollisols that have all of the following characteristics:

1. A mollic epipedon not more than 50 cm (20 inches) thick;
2. No argillic horizon;
3. No calcic horizon;
4. Material, including coarse fragments less than 7.5 cm (3 inches) in diameter, that has more than 40 percent calcium carbonate in or immediately below the mollic epipedon.

Rendolls, p. 132

GB. Other Mollisols that have:

1. An albic horizon immediately underlying the mollic epipedon, or that separates horizons that together meet all of the requirements of a mollic epipedon;
2. An argillic or natric horizon;
3. In the albic horizon and in the argillic or natric horizon, characteristics associated with wetness, namely: mottles, iron-manganese concretions larger than 2 mm, or both.

Albolls, p. 121

GBA. Albolls that have a natric horizon.

Natralbolls, p. 122

GBB. Other Albolls.

Argialbolls, p. 121

GC. Other Mollisols, either saturated with water at some period during the year or artificially drained, that have one or more of the following characteristics associated with wetness:

1. A histic epipedon;
2. Sodium saturation of more than 15 percent in the upper part of the mollic epipedon and decreasing saturation with increasing depth below 50 cm (20 inches);
3. One of the following combinations of moist colors, in and either immediately below the mollic epipedon or within 75 cm (30 inches) of the surface if a calcic horizon immediately underlies the mollic epipedon;
   a. If the lower part of the mollic epipedon has chromas of 1 or less there are either:
      (1) Distinct or prominent mottles in the lower mollic epipedon; or

* At present we are grouping a few soils with Mollisols that have epipedons meeting all requirements for a mollic epipedon except color value. These soils have more than 4 percent organic matter and more than 40 percent finely divided calcium carbonate throughout the epipedon. Some are grouped with Calciaquolls and some with Rendolls.

(2) Colors immediately below the mollic epipedon or within 75 cm (30 inches) of the surface if a calcic horizon intervenes, with one of the following:

(a) Where hues are 10YR or redder and there are mottles, chromas are less than 1.5 on ped surfaces or in the matrix; where there are no mottles, chromas are less than 1;

(b) Where the hue is nearest to 2.5Y and there are distinct or prominent mottles, chromas are 2 or less on ped surfaces or in the matrix; and where there are no mottles, chromas are 1 or less;

(c) Where the nearest hue is 5Y or yellower and there are distinct or prominent mottles, chromas are 3 or less on ped surfaces or in the matrix; and where there are no mottles, chromas are 1 or less;

(d) Hues are bluer than 10Y;

(e) The color results from uncoated mineral grains;

b. If the lower part of the mollic epipedon has chromas of more than 1 but not exceeding 2, there are either:

(1) Distinct or prominent mottles in the lower mollic epipedon; or

(2) Base colors immediately below the mollic epipedon that have one or more of:

(a) Values of 4 and chromas of 2 accompanied by some mottles with values of 4 or more and chromas of less than 2;

(b) Values of 5 or more and chromas of 2 or less accompanied by mottles with higher chroma;

(c) Values of 4 and chromas of less than 2.

4. A calcic horizon with its upper boundary within 40 cm (16 inches) of the surface.

Aquolls, p. 122

GCA. Aquolls that have a mean annual soil temperature of less than 8°C (47°F) and the mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, is less than 15°C (59°F) if the soil is drained and has no O horizon or histic epipedon; less than 8°C (47°F) if drained and with an O horizon; and less than 6°C (43°F) if the soil is undrained and has an O horizon or a histic epipedon.

Cryaquolls, p. 124

GCB. Other Aquolls that have a duripan within 1 m (40 inches) of the surface.

Duraquolls, p. 125

GCC. Other Aquolls that have a natric horizon.

Natraquolls, p. 126

GCD. Other Aquolls that have a calcic horizon with its upper boundary within 40 cm (16 inches) of the surface, and lack an argillic horizon unless it is a buried horizon.

Calciaquolls, p. 124

GCE. Other Aquolls that have an argillic horizon.

Argiaquolls, p. 123

GCF. Other Aquolls.

Haplaquolls, p. 125

GD. Other Mollisols that have a mean annual soil temperature of less than 8°C (47°F); and either a moist chroma of 1.5 or less in the mollic epipedon to a depth of 15 cm (6 inches) or more or a mean summer soil temperature at 50 cm (20 inches) or a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if without an O horizon and less than 8°C (47°F) if with an O horizon.

Borolls, p. 126

GDA. Borolls that have an argillic horizon with an upper boundary deeper than 60 cm * (24 inches) below the mineral surface and with textures finer than loamy fine sand in all subhorizons above the argillic horizon.

Paleborolls, p. 131

* If there is a surface mantle that has more than 60 percent vitric volcanic ash, cinders or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral surface.

KEY

GG. Other Mollisols.

Udolls, p. 133

GGA. Udolls that have an argillic horizon with a clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface and with one or both:
1. Hues are redder than 10YR with chromas of more than 4 dominant in the matrix in at least the lower part of the argillic horizon;
2. There are many coarse mottles that have hues redder than 7.5YR or chromas of more than 5.

Paleudolls, p. 136

GGB. Other Udolls that have an argillic horizon.

Argiudolls, p. 134

GGC. Other Udolls that have a mollic epipedon that, below any Ap, is 50 percent or more by volume of worm holes, worm casts, or filled animal burrows and that either rests on a lithic contact or has a transition to the underlying horizon in which 25 percent or more of the material is discrete worm holes, worm casts, or filled animal burrows from the mollic epipedon and the underlying horizon.

Vermudolls, p. 136

GGD. Other Udolls.

Hapludolls, p. 134

H. Other mineral soils that lack an oxic horizon unless it underlies an argillic horizon, and that have one of the following combinations of properties:

1. No fragipan; an argillic or natric horizon; are usually moist in some part of the soil between 18 cm and 50 cm(7 and 20 inches) unless the epipedon is both hard and massive when dry; and base saturation (by sum of cations) is 35 percent or more at a depth of 1.25 m (50 inches) below the top of the argillic horizon or at 1.8 m (72 inches) below the soil surface or immediately above a lithic or a paralithic contact, whichever is shallower;
2. With a fragipan in or below the argillic horizon or with oriented clay skins 1 mm or more thick in some part of the fragipan; and base saturation (by sum of cations) of 35 percent or more at a depth of 75 cm (30 inches) below the upper boundary of the fragipan or immediately above a lithic or a paralithic contact, whichever is shallower.

ORDER 7 - Alfisols, p. 160

HA. Alfisols, either saturated with water at some season or artificially drained, that have characteristics associated with wetness, namely: mottles, iron-manganese concretions larger than 2 mm, or chromas of 2 or less immediately below any Ap horizon or below any dark A1 that has moist values of less than 3.5 when rubbed, and one of the following:

1. Dominant chromas of 2 * or less in coatings on the surface of peds accompanied by mottles within the peds, or dominant chromas of 2 or less in the matrix of the argillic horizon accompanied by mottles of higher chromas;
2. If there are no mottles in the argillic horizon, chromas are 1 or less.

Aqualfs, p. 160

HAA. Aqualfs that have a natric horizon.

Natraqualfs, p. 162

HAB. Other Aqualfs that have a mean annual soil temperature of 8°C (47°F) or higher and mean summer and mean winter soil temperatures at 50 cm (20 inches) or above a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Tropaqualfs, p. 163

HAC. Other Aqualfs that have a fragipan.

Fragiaqualfs, p. 161

HAD. Other Aqualfs that have an albic horizon tonguing into an argillic horizon and that lack a duripan.

Glossaqualfs, p. 161

* If hues are redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived.

KEY

HDD. Other Xeralfs that have an argillic horizon that in all parts has colors in hues redder than 5YR and moist values of less than 4 and dry values no more than 1 unit higher than moist values, and that have no petrocalcic horizon within 1.5 m (60 inches) of the soil surface.

Rhodoxeralfs, p. 183

HDE. Other Xeralfs that have a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface, or an argillic horizon with one or both:

1. A vertical clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface, and one or more of:
   a. Hues redder than 10YR and chromas of more than 4 in the matrix;
   b. Common coarse mottles with hues of 7.5YR or redder or chromas of more than 5;
2. A particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary.

Palexeralfs, p. 182

HDF. Other Xeralfs.

Haploxeralfs, p. 180

HE. Other Alfisols.

Udalfs, p. 168

HEA. Udalfs that have an agric horizon.

Agrudalfs, p. 168

HEB. Other Udalfs that have a fragipan.

Fragiudalfs, p. 168

HEC. Other Udalfs that have a natric horizon.

Natrudalfs, p. 172

HED. Other Udalfs that have mean summer and mean winter soil temperatures at 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Tropudalfs, p. 173

HEE. Other Udalfs that have:

1. No continuous albic horizon above the argillic horizon;
2. A broken upper boundary of the argillic horizon;
3. Discrete nodules in the argillic horizon that range from 2.5 to 5 cm (1 to 2 inches) up to about 30 cm (12 inches) in diameter; exteriors of nodules are enriched and weakly cemented or indurated with iron and have redder hues or stronger chromas than interiors of nodules.

Ferrudalfs, p. 168

HEF. Other Udalfs that have an irregular or broken upper boundary of the argillic horizon with tongues of an albic or other eluvial horizon.

Glossudalfs, p. 169

HEG. Other Udalfs that have an argillic horizon with a clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface, and with one or more of the following:

1. Hues are redder than 10YR with chromas of more than 4 dominant in the matrix in at least the lower part of the argillic horizon;
2. Hues are 2.5YR or redder and moist values are less than 4 and dry values are less than 5 throughout the major part of the argillic horizon;
3. There are many coarse mottles that have hues redder than 7.5YR or chromas of more than 5, or both.

Paleudalfs*, p. 172

*Great group names and definitions are being proposed for criticism.

KEY

ICC. Other Ustox.

Haplustox, p. 203

ID. Other Oxisols that:

1. Are always moist or have no period when the soil is dry in any horizon below the surface 18 cm (7 inches) for 60 consecutive days or more in most years.
2. Have 20 kg or more organic carbon per m^2 to a depth of 1 m (40 inches), exclusive of organic surface litter;
3. Have base saturation (by NH_4OAc) of less than 35 percent in the oxic horizon;
4. Have a mean annual soil temperature of less than 22°C (72°F).

Humox, p. 199

IDA. Humox that have an oxic horizon with a subhorizon that is darker in color and contains more organic carbon than the overlying subhorizon.

Sombrihumox, p. 200

IDB. Other Humox that have within 1 m (40 inches) of the surface, cemented sheets or a subhorizon with 20 percent or more by volume of gravel-size aggregates that contain 30 percent or more gibbsite.

Gibbsihumox, p. 199

IDC. Other Humox that have in all subhorizons of the oxic horizon, a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 g clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 g of clay.

Haplohumox, p.200

IDD. Other Humox.

Acrohumox, p. 199

IE. Other Oxisols that have no period when the soil is dry in any horizon below the surface 18 cm (7 inches) for 60 consecutive days or more in most years and either:

1. Have a mean annual soil temperature of 22°C (72°F) or more; or
2. Have less than 20 kg organic carbon per m^2 within 1 m (40 inches).

Orthox, p. 200

IEA. Orthox that have within 1.25 m (50 inches) of the surface sheets containing 30 percent or more gibbsite or a subhorizon with 20 percent or more by volume of gravel-size aggregates containing 30 percent or more gibbsite.

Gibbsiorthox, p. 201

IEB. Other Orthox that have:

1. In some subhorizon of the oxic horizon, a cation retention capacity of 1 meq or less (from NH_4Cl) per 100 g of clay (or 1 meq or less of extractable bases plus extractable aluminum per 100 g of clay);
2. No discernible structure in the oxic horizon or only very weak blocky or prismatic peds.

Acrorthox, p. 200

IEC. Other Orthox that have no anthropic epipedon and have base saturation of 35 percent or more (by NH_4OAc) in the epipedon and in all subhorizons of the oxic horizon to a depth of at least 1.25 m (50 inches).

Eutrorthox, p. 201

IED. Other Orthox that have either an umbric epipedon or an ochric epipedon that has more than 1 percent carbon in all subhorizons to 75 cm (30 inches) or more below the top of the mineral surface.

Umbriorthox, p. 202

IEE. Other Orthox.

Haplorthox, p.201

Typic Cryofluvents--Cont.

b. have no mottles with chromas of 2 or less within 50 cm (20 inches) of the surface;

c. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at at depth of 50 cm (20 inches) that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon; and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Andic Cryofluvents. Cryofluvents like the Typic except for a.

Aquic Cryofluvents. Cryofluvents like the Typic except for b.

Torrifluvents. Fluvents that

1. are warmer than Cryofluvents;

2. are usually dry in most years in all parts of the soil between 18 and 50 cm (7 and 20 inches).

Typic Torrifluvents. Torrifluvents that

a. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

b. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon; and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;

c. have no prismatic or blocky structure with clay films on ped faces that have color values lower than in the matrix within 1 m (40 inches) of the soil surface.

Durorthidic Torrifluvents. Torrifluvents like the Typic except for a.

Vertic Torrifluvents. Torrifluvents like the Typic except for b.

Tropofluvents. Fluvents that

1. have a mean annual soil temperature of 8°C (47°F) or more and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by less than 5°C (9°F);

2. are not dry in more than 7 out of 10 years in all subhorizons between 18 and 50 cm (7 and 20 inches) for as much as 60 consecutive days, and are not dry in some subhorizon between these depths for as much as 90 cumulative days in most years .

Typic Tropofluvents. Tropofluvents that

a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

b. have no mottles within 50 cm (20 inches) of the surface with chromas of 2 or less, or, at depths between 50 cm and 1 m (20 and 40 inches) have no horizons that are saturated with water at some period or that are artificially drained and that have chromas of less than 1 or hues bluer than 10Y;

c. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick, that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

d. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon; and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon, or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Andic Tropofluvents. Tropofluvents like the Typic except for a.

Aquic Tropofluvents. Tropofluvents like the Typic except for b.

Durorthidic Tropofluvents. Tropofluvents like the Typic except for c.

Vertic Tropofluvents. Tropofluvents like the Typic except for d.

Udifluvents. Fluvents that

1. have soil temperatures warmer than those of Cryofluvents, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;

2. are not dry in all subhorizons between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as much as 60 consecutive days, and are not dry in some subhorizon between these depths for as much as 90 cumulative days in most years.

Typic Udifluvents. Fluvents that

a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;

b. have no mottles within 50 cm (20 inches) of the surface with chromas of 2 or less, or at depths between 50 cm and 1 m (20 and 40 inches) have no horizons that are saturated with water at some period or that are artificially drained and that have chromas of less than 1 or hues bluer than 10Y;

c. have no buried mollic epipedon that is 20 cm (8 inches) or more thick and that has its upper boundary within 50 cm (20 inches) of the surface;

d. lack the following combination of characteristics:

Typic Cryorthents. Cryorthents that

a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;

b. have no mottles with chromas of 2 or less within 50 cm (20 inches) of the surface;

c. have no lithic contact within 50 cm (20 inches) of the surface;

d. have a mean annual soil temperature of more than 0°C (32°F);

e. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon; and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;

f. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix, or is brittle and has firm consistence when moist.

Andic Cryorthents. Cryorthents like the Typic except for a.

Andic Aquic Cryorthents. Cryorthents like the Typic except for a and b.

Aquic Cryorthents. Cryorthents like the Typic except for b.

Lithic Cryorthents. Cryorthents like the Typic except for c.

Pergelic Cryorthents. Cryorthents like the Typic except for d.

Vertic Cryorthents. Cryorthents like the Typic except for e.

Torriorthents. Orthents that

1. have soil temperatures warmer than those of Cryorthents;

2. are usually dry in most years in all parts of the soil between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in some subhorizon above a lithic or a paralithic contact shallower than 18 cm (7 inches).

Typic Torriorthents. Torriorthents that

a. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

b. have no lithic contact within 50 cm (20 inches) of the surface;

c. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon; and

Typic Xerorthents--Cont.

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Xerorthents. Xerorthents like the Typic except for a.

Aquic Durorthidic Xerorthents. Xerorthents like the Typic except for a and b.

Lithic Xerorthents. Xerorthents like the Typic except for c.

Vertic Xerorthents. Xerorthents like the Typic except for d.

Psamments. Entisols that

1. have below the Ap horizon or 25 cm (10 inches), whichever is deeper, textures of loamy fine sand or coarser in all parts either to a depth of 1 m (40 inches) or to a lithic or a paralithic contact, whichever is shallower;

2. have no fragments of diagnostic horizons that can be identified and that occur more or less without discernible order in the soil below any Ap horizon but within the series control section.

3. are not permanently saturated with water and lack the characteristics associated with wetness defined for Aquents.

Cryopsamments. Psamments that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of either less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon.

Typic Cryopsamments. Cryopsamments that

a. have no lamellae within 1.5 m (60 inches) of the soil surface that meet all requirements for an argillic horizon except thickness;

b. have no mottles with chromas of 2 or less within 50 cm (20 inches) of the surface;

c. have a mean annual soil temperature of more than 0°C (32°F).

d. have no lithic contact within 50 cm (20 inches) of the surface.

Alfic Cryopsamments. Cryopsamments like the Typic except for a and have base saturation of 35 percent or more in some horizon less than 1.25 m (50 inches) below the uppermost lamellae.

Aquic Cryopsamments. Cryopsamments like the Typic except for b.

Aquic Pergelic Cryopsamments. Cryopsamments like the Typic except for b and c.

Lithic Cryopsamments. Cryopsamments like the Typic except for d.

Quartzipsamments. Psamments that

1. have soil temperatures warmer than those of Cryopsamments;

2. have a sand fraction that is more than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or aluminum;

Typic Quartzipsamments. Quartzipsamments that

a. have no mottles to a depth of 1 m (40 inches) that have chromas of 2 or less, or if the color is due to uncoated sand grains, a ground water table is within 1 m (40 inches) of the soil surface for less than 60 cumulative days in most years;

b. have no albic horizon at the surface or immediately underlying an A1 or Ap horizon that is underlain by another horizon having values more than 1 unit darker or having chromas of 6 or more;

Typic Quartzipsamments--Cont.

c. have no lithic contact within 50 cm (20 inches) of the surface;

d. have a clay fraction with a higher CEC than that of the clay of an oxic horizon;

e. have less than 5 percent plinthite in all horizons to a depth of 1 m (40 inches).

Aquic Quartzipsamments. Quartzipsamments like the Typic except for a.

Aquodic Quartzipsamments. Quartzipsamments like the Typic except for b and have a ground water table within 1 m (40 inches) of the soil surface for 6 months or more in most years, or are artificially drained, and lack sufficient free iron to turn redder on ignition.

Lithic Quartzipsamments. Quartzipsamments like the Typic except for c.

Lithic Spodic Quartzipsamments. Quartzipsamments like the Typic except for b and c.

Oxic Quartzipsamments. Quartzipsamments like the Typic except for d with or without e.

Spodic Quartzipsamments. Quartzipsamments like the Typic except for b.

Torripsamments. Psamments that

1. have soil temperatures warmer than those of Cryopsamments;

2. are usually dry in most years in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or paralithic contact shallower than 50 cm (20 inches) or in some subhorizon above a lithic or a paralithic contact shallower than 18 cm (7 inches);

3. have in the sand fraction, less than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluable minerals that do not weather to liberate iron or aluminum;

Typic Torripsamments. Torripsamments that

a. have no lithic contact within 50 cm (20 inches) of the surface;

b. have no lamellae within 1.5 m (60 inches) of the soil surface that meet all requirements for an argillic horizon except thickness; *

c. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist.

Lithic Torripsamments. Torripsamments like the Typic except for a.

Udipsamments. Psamments that

1. have soil temperatures warmer than those of Cryopsamments and mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F), or more;

2. are not dry in all subhorizons between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in all subhorizons above a lithic or a paralithic contact shallower than 18 cm (7 inches) in more than 7 out of 10 years for as much as 60 consecutive days, and are not dry in some subhorizon between these depths for as much as 90 cumulative days in most years;

3. have in the sand fraction, less than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or aluminum.

Typic Udipsamments. Udipsamments that

a. have no lamellae within 1.5 m (60 inches) of the soil surface that meet all requirements for an argillic horizon except thickness; *

b. have no mottles with chromas of 2 or less to a depth of 1 m (40 inches);

* Clay content cannot be estimated with precision in lamella that are very thin. The lamella in alfic subgroups are usually observed to be about 0.5 to 1 cm thick but the total thickness is less than the required 15 cm (6 inches) for an argillic horizon.

Xeropsamments--Cont.

2. are usually moist but are dry for 60 consecutive days or more in more than 7 out of 10 years in all subhorizons between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches);

3. have in the sand fraction, less than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or aluminum.

Typic Xeropsamments. Xeropsamments that

a. have no lamellae within 1.5 m (60 inches) of the soil surface that meet all requirements for an argillic horizon except thickness; *

b. have no mottles with chromas of 2 or less to a depth of 1 m (40 inches);

c. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a non-brittle matrix or is brittle and has firm consistence when moist;

d. have no lithic contact within 50 cm (20 inches) of the surface.

Alfic Xeropsamments. Xeropsamments like the Typic except for a and have base saturation of 35 percent or more in some horizon less than 1.25 m (50 inches) below the uppermost lamellae.

Aquic Xeropsamments. Xeropsamments like the Typic except for b.

* Clay content cannot be estimated with precision in lamella that are very thin. The lamella in alfic subgroups are usually observed to be about 0.5 to 1 cm thick but the total thickness is less than the required 15 cm (6 inches) for an argillic horizon.

Usterts. Vertisols that have cracks that remain open for 90 cumulative days or more during the year but not throughout the year in most years and one or more of the following:

1. cracks that open and close more than once during the year in most years;

2. a mean annual soil temperature of 22°C (72°F) or more;

3. a mean summer and mean winter soil temperature at 50 cm (20 inches) depth that differ by less than 5°C (9°F).

Chromusterts. Usterts that have moist chromas of 1.5 or more throughout the upper 30 cm (12 inches) in more than half of each pedon.

Typic Chromusterts. Chromusterts that

a. have color values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm (12 inches) in more than half of each pedon;

b. lack a prismatic or blocky structure with clay skins on ped faces that have color values lower than in the matrix within 1 m (40 inches) of the soil surface;

c. have cracks that remain open for more than 150 cumulative days during the year if mean annual soil temperature is more than 15°C (59°F).

Entic Chromusterts. Chromusterts like the Typic except for a.

Paleustollic Chromusterts. Chromusterts like the Typic except for b.

Udic Chromusterts. Chromusterts like the Typic except for c and have cracks that remain open from 90 to 150 cumulative days during the year.

Udorthentic Chromusterts. Chromusterts like the Typic except for a and c.

Pellusterts. Usterts that have moist chromas less than 1.5 throughout the upper 30 cm (12 inches), in more than half of each pedon.

Typic Pellusterts. Pellusterts that

a. have in all subhorizons to a depth of 1 m (40 inches) dry and moist chromas of less than 1.5, or if chromas are 1.5 or higher there are distinct or prominent mottles or concretions due to segregated Fe or Mn;

b. have color values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm (12 inches) in more than half of each pedon;

c. have cracks that remain open for more than 150 cumulative days during the year if the mean annual soil temperature is more than 15°C (59°F);

d. lack a prismatic or blocky structure with clay skins on ped faces that have color values lower than in the matrix within 1 m (40 inches) of the soil surface.

Chromic Pellusterts. Pellusterts like the Typic except for a.

Chromic Entic Pellusterts. Pellusterts like the Typic except for a and b.

Chromudic Pellusterts. Pellusterts like the Typic except for a and c.

Entic Pellusterts. Pellusterts like the Typic except for b.

Paleustollic Pellusterts. Pellusterts like the Typic except for d with or without c.

Udic Pellusterts. Pellusterts like the Typic except for c.

Udorthentic Pellusterts. Pellusterts like the Typic except for b and c.

Xererts. Vertisols that have cracks that open and close once each year and remain open for 60 consecutive days or more in more than 7 out of 10 years and have mean annual soil temperatures less than 22°C (72°F), and mean summer and mean winter soil temperatures at 50 cm depth (20 inches) that differ by 5°C (9°F) or more.

Chromoxererts. Xererts that have moist chromas of 1.5 or more throughout the upper 30 cm (12 inches) in more than half of each pedon.

Typic Chromoxererts. Chromoxererts that

a. lack distinct or prominent mottles within 50 cm (20 inches) of the surface;

b. have color values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm (12 inches) in more than half of each pedon.

Aquic Chromoxererts. Chromoxererts like the Typic except for a.

Aquic Entic Chromoxererts. Chromoxererts like the Typic except for a and b.

Entic Chromoxererts. Chromoxererts like the Typic except for b.

Pelloxererts. Xererts that have moist chromas less than 1.5 throughout the upper 30 cm (12 inches) in more than half of each pedon.

Typic Pelloxererts. Pelloxererts that

a. have in all subhorizons to a depth of 1 m (40 inches) dry and moist chromas of less than 1.5, or if chromas are 1.5 or higher there are distinct or prominent mottles or concretions due to segregated Fe or Mn;

b. have color values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm (12 inches) in more than half of each pedon.

Chromic Pelloxererts. Pelloxererts like the Typic except for a.

Chromic Entic Pelloxererts. Pelloxererts like the Typic except for a and b.

Entic Pelloxererts. Pelloxererts like the Typic except for b.

INCEPTISOLS: ORDER 3

Inceptisols are mineral soils that have no spodic, argillic, natric, or oxic horizon unless it is a buried horizon; that have no plinthite that forms a continuous phase within 30 cm (12 inches) of the mineral surface; and either:

1. Are usually moist between 18 and 50 cm (7 and 20 inches) or above a lithic or a paralithic contact shallower than 50 cm (20 inches); that lack a salic, or gypsic horizon within 1 m (40 inches) of the surface; and that have one or more of the following:
   a. A conductivity of the saturation extract at 25°C (77°F) of less than 2 mmho per cm down to whichever of these depths is least: a lithic or a paralithic contact or within 1.25 m (50 inches) of the surface if particle-size classes are sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey; and, if without a fragipan, with increase in depth in the C horizon but above the depths for the different particle-size classes specified above, either there is no increase in saturation with Na plus K or there is exchange acidity in excess of Na plus K; and with one or more of:
      (1) A cambic or a calcic horizon or both;
      (2) A fragipan that has no clay skins as thick as 1 mm;
      (3) A duripan with its upper boundary within 1 m (40 inches) of the surface.
   b. Artificial drainage or saturation with water at some period of the year when not frozen, and at depths of less than 50 cm (20 inches) or immediately underlying an umbric epipedon, have a horizon with dominant moist colors on ped faces, or in the matrix if peds are absent, as follows:
      (1) If there is mottling, chromas are 2 or less;
      (2) If there is no mottling, chromas are 1 or less*.
   c. Sodium saturation of more than 15 percent in some part of the upper 50 cm (20 inches) that decreases with depth below 50 cm (20 inches) and the soil is saturated with water at some period within a depth of 1 m (40 inches); or
2. Have an umbric, histic, or plaggen epipedon; or a mollic epipedon with one or more of the following combinations of properties:
   a. A bulk density** of the fine earth fraction of less than 0.85 g per cc in the epipedon or the cambic horizon or both, and the exchange complex is dominated by amorphous materials;
   b. A underlying cambic horizon with base saturation of less than 50 percent (by NH_4OAc) throughout or decreasing to less than 50 percent at a depth of 1.8 m (72 inches) below the surface, whichever is shallower;
   c. The mean summer and mean winter soil temperatures differ by less than 5°C (9°F) when measured at a depth of 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, and one or both of:
      (1) 35 percent or more clay with montmorillonitic mineralogy, and the epipedon rests on materials with less than 40 percent $CaCO_3$ equivalent;
      (2) ~~a cambic horizon with base saturation that is less than 50 percent (by NH_4OAc) throughout or decreasing to less than 50 percent at a depth of 1.8 m (72 inches).~~

Andepts. Inceptisols that moist and dry values of the mollic epipedon are no darker than those of the underlying horizon

1. have one or both of:
   a. a bulk density of the fine earth fraction of the soil of less than 0.85 g per cc in the epipedon or the cambic horizon, or both, and the exchange complex is dominated by amorphous material;
   b. more than 60 percent of vitric volcanic ash, cinders, or other vitric pyroclastic material in the silt, sand, and gravel fractions;
2. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aquepts;
3. lack a plaggen epipedon.

* If hues are redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived.

** Bulk density at field capacity (1/3-bar tension).

Eutrandepts--Cont.

2. have soil temperatures warmer than those of Cryandepts;
3. lack clays that dehydrate irreversibly into gravel-size aggregates;
4. lack a duripan within 1 m (40 inches) or a fragipan.

Typic Eutrandepts. Eutrandepts that

a. lack mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
b. have a mollic epipedon 25 cm (10 inches) or more thick;
c. lack a lithic contact within 50 cm (20 inches) of the surface;
d. lack a subhorizon with soft, powdery, secondary lime within 1.5 m (60 inches) of the surface.

Aquic Eutrandepts. Eutrandepts like the Typic except for a.

Entic Eutrandepts. Eutrandepts like the Typic except for b.

Lithic Eutrandepts. Eutrandepts like the Typic except for c.

Lithic Ustollic Eutrandepts. Eutrandepts like the Typic except for c and d.

Ustollic Eutrandepts. Eutrandepts like the Typic except for d.

Hydrandepts. Andepts that

1. have clays that dehydrate irreversibly into gravel-size aggregates;
2. have soil temperatures warmer than those of Cryandepts.

Typic Hydrandepts. Hydrandepts that

a. lack a lithic contact within 50 cm (20 inches) of the surface.

Lithic Hydrandepts. Hydrandepts like the Typic except for a.

Vitrandepts. Andepts that

1. are not thixotropic and the 15-bar water retention is less than 20 percent based on the average for the whole soil between 25 cm and 1 m (10 and 40 inches) or a lithic or paralithic contact, whichever is shallower;
2. have soil temperatures warmer than those of Cryandepts;
3. lack clays that dehydrate irreversibly into gravel-size aggregates;
4. lack a duripan within 1 m (40 inches).

Typic Vitrandepts. Vitrandepts that

a. lack mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
b. lack a lithic contact within 50 cm (20 inches) of the surface;
c. have an ochric epipedon.

Aquic Vitrandepts. Vitrandepts like the Typic except for a.

Lithic Vitrandepts. Vitrandepts like the Typic except for b.

Lithic Mollic Vitrandepts. Vitrandepts like the Typic except for b and c and have a mollic epipedon.

Lithic Umbric Vitrandepts. Vitrandepts like the Typic except for b and c and have an umbric epipedon.

Mollic Vitrandepts. Vitrandepts like the Typic except for c and have a mollic epipedon.

Umbric Vitrandepts. Vitrandepts like the Typic except for c and have an umbric epipedon.

Typic Cryaquepts. Cryaquepts that

a. have in 60 percent or more of the mass of all horizons between 15 and 50 cm (6 and 20 inches), chromas of 2 or less;

b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

c. lack a histic epipedon;

d. lack an umbric or a mollic epipedon;

e. lack a lithic contact within 50 cm (20 inches) of the surface;

f. have a mean annual soil temperature of more than 0°C (32°F).

Aeric Cryaquepts. Cryaquepts like the Typic except for a.

Aeric Humic Cryaquepts. Cryaquepts like the Typic except for a and d.

Andic Cryaquepts. Cryaquepts like the Typic except for b or b and d.

Andic Histic Cryaquepts. Cryaquepts like the Typic except for b and c.

Histic Cryaquepts. Cryaquepts like the Typic except for c or c and d.

Histic Lithic Pergelic Cryaquepts. Cryaquepts like the Typic except for c, e and f.

Histic Pergelic Cryaquepts. Cryaquepts like the Typic except for c and f.

Humic Cryaquepts. Cryaquepts like the Typic except for d.

Lithic Pergelic Cryaquepts. Cryaquepts like the Typic except for e and f.

Pergelic Cryaquepts. Cryaquepts like the Typic except for f.

Fragiaquepts. Aquepts that

1. have a fragipan;
2. have soil temperatures warmer than those of Cryaquepts;
3. have less than 15 percent saturation with sodium in the upper 50 cm (20 inches) or have saturation with sodium that is constant or increases with depth below 50 cm (20 inches);
4. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Fragiaquepts. Fragiaquepts that

a. have an ochric epipedon;

b. have colors diagnostic of the Aquepts in all horizons below the plow layer or, if there is no plow layer, below 15 cm (6 inches) and down to a depth of 75 cm (30 inches) or more.

Aeric Fragiaquepts. Fragiaquepts like the Typic except for b.

Humic Fragiaquepts. Fragiaquepts like the Typic except for a.

Halaquepts. Aquepts that

1. have sodium saturation that is 15 percent or more in some part of the upper 50 cm (20 inches) and that decreases with depth below 50 cm (20 inches) and the soil is saturated with water at some period within a depth of 1 m (40 inches).

2. have an N value of 0.5 or less in some layer between 20 and 50 cm (8 and 20 inches);

3. have soil temperatures warmer than those of Cryaquepts;

4. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Halaquepts. Halaquepts that

a. have chromas of 2 or less in hues of 5Y or redder in 60 percent or more of the matrix in all subhorizons between 15 and 75 cm (6 and 30 inches);

b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

c. have an organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) within 1.25 m (50 inches) of the surface;

d. have an ochric epipedon.

Aeric Halaquepts. Halaquepts like the Typic except for a.
Aeric Andic Halaquepts. Halaquepts like the Typic except for a and b.
Andic Halaquepts. Halaquepts like the Typic except for b.

Fluventic Halaquepts. Halaquepts like the Typic except for c with or without a.

Haplaquepts. Aquepts that

1. have soil temperatures warmer than those of Cryaquepts and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;

2. have an ochric epipedon;

3. have an exchange complex that is dominated by crystalline aluminosilicate clay minerals and have less than 60 percent vitric volcanic ash, cinders, or other vitric pyroclastic materials in the silt, sand, and gravel fractions;

4. have an N value of 0.5 or less in some layer between 20 and 50 cm (8 and 20 inches);

5. have less than 15 percent saturation with sodium in the upper 50 cm (20 inches) or with saturation that is constant or increases with depth below 50 cm (20 inches);

6. lack a fragipan;

7. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Haplaquepts. Haplaquepts that

a. have in 60 percent or more of the matrix in all subhorizons between the A1 or Ap and 75 cm (30 inches) one or more of the following:

(1) if mottled and mean annual soil temperature is less than 15°C (59°F) moist chromas are 2 or less;

(2) if mottled and mean annual soil temperature is 15°C (59°F) or more:

Typic Haplaquepts--Cont.

(a) in hues of 2.5Y or redder* and moist values more than 5, moist chromas are 2 or less,

(b) in hues of 2.5Y or redder and moist values of 5 or less, moist chromas are 1 or less,

(c) in hues yellower than 2.5Y, moist chromas are 2 or less;

(3) moist chromas are 1 or less with or without mottles.

b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

c. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;

d. lack a buried Histosol within 50 cm (20 inches) of the surface;

e. have an Ap horizon with a moist value of 4 or more or with a dry value of 6 or more crushed and smoothed** or the A1 horizon is less than 15 cm (6 inches) thick if its moist color value is lower than 3.5;

f. have an N value of less than 0.9 between 50 and 80 cm (20 and 32 inches) and less than 0.5 in all layers between 30 and 50 cm (12 and 20 inches);

g. lack a lithic contact within 50 cm (20 inches) of the surface;

h. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend to the surface or to the base of an Ap horizon; and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aeric Haplaquepts. Haplaquepts like the Typic except for a or a and e.

Aeric Andic Haplaquepts. Haplaquepts like the Typic except for a and b.

Chromudertic Haplaquepts. Haplaquepts like the Typic except for a, c and h with or without e.

Fluventic Haplaquepts. Haplaquepts like the Typic except for c with or without a or e, or both.

Humic Haplaquepts. Haplaquepts like the Typic except for e and the base saturation is less than 50 percent in some horizon and does not increase with depth to 50 percent or more.

Lithic Haplaquepts. Haplaquepts like the Typic except for g.

Mollic Haplaquepts. Haplaquepts like the Typic except for e and the base saturation is 50 percent or more throughout or increases with depth to 50 percent or more.

Thapto-Histic Haplaquepts. Haplaquepts like the Typic except for c and d.

Vertic Haplaquepts. Haplaquepts like the Typic except for c and h with or without e.

* If hues are 7.5YR or redder in the matrix: if peds are present, ped exteriors have dominant moist chromas of 1 or less and ped interiors have mottles with moist chromas of 2 or less; if peds are absent, moist chromas are 1 or less immediately below any surface horizon that has moist values of less than 3.5.

** Use knife and smooth to eliminate shadows.

Humaquepts. Aquepts that

1. have soil temperatures warmer than those of Cryaquepts and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;

2. have an umbric, mollic or a histic epipedon;

3. have an exchange complex that is dominated by crystalline aluminosilicate clay minerals and have less than 60 percent vitric volcanic ash, cinders or other vitric pyroclastic materials in the silt, sand, and gravel fractions;

4. have an N value of 0.5 or less in some layer between 20 and 50 cm (8 and 20 inches);

5. have less than 15 percent saturation with sodium in the upper 50 cm (20 inches) or have saturation with sodium that is constant or increases with depth below 50 cm (20 inches);

6. lack a fragipan;

7. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Humaquepts. Humaquepts that

a. have chromas of 2 or less in hues of 5Y or redder in 60 percent or more of the matrix in all subhorizons between 15 and 75 cm (6 and 30 inches);

b. have mottles within 30 cm (12 inches) below the base of the epipedon if the chromas to this depth are 1 or more and the hues are redder than 5Y;

c. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

d. have an epipedon less than 60 cm (24 inches) thick;

e. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;

f. lack a histic epipedon;

g. have an N value of less than 0.9 between 50 and 80 cm (20 and 32 inches) depths;

h. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon; and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon, or horizons, at least 50 cm (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aeric Humaquepts. Humaquepts like the Typic except for a or b or both.

Cumulic Humaquepts. Humaquepts like the Typic except for d and e.

Dystrochrepts. Ochrepts that

1. lack carbonates in the cambic horizon or in the C horizon within the soil;
2. have a base saturation less than 60 percent (by NH_4OAc) in all subhorizons that are within 75 cm (30 inches) of the soil surface;
3. are not dry for as much as 90 cumulative days in most years in any subhorizon of the soil between 18 and 50 cm (7 and 20 inches) or above a lithic or paralithic contact shallower than 50 cm (20 inches) and are not dry for as much as 60 consecutive days in more than 7 out of 10 years in all subhorizons between these depths;
4. lack a fragipan and lack a duripan with its upper boundary within 1 m (40 inches) of the soil surface;
5. have a mean annual soil temperature of 8°C (47°F) or more or have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of either 15°C (59°F) or more if cultivated or without an O horizon or 8°C (47°F) or more if with an O horizon.

Typic Dystrochrepts. Dystrochrepts that

a. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

b. lack mottles with chromas of 2 or less within 50 cm (20 inches) of the surface;

c. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;

d. lack a lithic contact within 50 cm (20 inches) of the surface;

e. lack an argillic horizon in any part of the pedon;

f. lack an umbric or mollic epipedon.

Andic Dystrochrepts. Dystrochrepts like the Typic except for a.

Andic Aquic Dystrochrepts. Dystrochrepts like the Typic except for a and b.

Andic Umbric Dystrochrepts. Dystrochrepts like the Typic except for a and f.

Aquic Dystrochrepts. Dystrochrepts like the Typic except for b.

Aquic Fluventic Dystrochrepts. Dystrochrepts like the Typic except for b and c.

Fluventic Dystrochrepts. Dystrochrepts like the Typic except for c.

Fluventic Umbric Dystrochrepts. Dystrochrepts like the Typic except for c and f.

Lithic Dystrochrepts. Dystrochrepts like the Typic except for d.

Lithic Ruptic-Alfic Dystrochrepts. Dystrochrepts like the Typic except for d and e and base saturation (by sum of cations) is 35 percent or more in some part above the lithic contact but in less than half of each pedon.

Lithic Ruptic-Ultic Dystrochrepts. Dystrochrepts like the Typic except for d and e and base saturation (by sum of cations) is less than 35 percent above the lithic contact but in less than half of each pedon.

Ruptic-Alfic Dystrochrepts. Dystrochrepts like the Typic except for e and the base saturation (by sum of cations) is 35 percent or more at a depth of 1.25 m (50 inches) below the upper boundary of the argillic horizon but in less than half of each pedon.

Ustochrepts--Cont.

2. lack a fragipan and lack a duripan with its upper boundary within 1 m (40 inches) of the soil surface;
3. have a mean annual soil temperature of 8°C (47°F) or more or have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of either 15°C (59°F) or more if cultivated or without an O horizon or 8°C (47°F) or more if with an O horizon.

Typic Ustochrepts. Ustochrepts that

a. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;

b. have no lithic contact within 50 cm (20 inches) of the surface;

c. have less than 40 percent carbonates below the cambic horizon to a depth of 1 m (40 inches).

d. lack both of the following combinations of characteristics:

(1) (a) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches) and that are at lesst 30 cm (12 inches) long in some part and that extend to the surface or the base of an Ap, and

(b) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(c) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;

(2) (a) have a lithic or paralithic contact or altered rock retaining its rock structure within 50 cm (20 inches) of the surface, and

(b) have horizons totalling 25 cm (10 inches) or more in thickness with 35 percent or more clay with montmorillonitic mineralogy.

e. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;

f. have base saturation (by NH_4OAc) of 60 percent or more in some part of the soil within 75 cm (30 inches) of the surface;

Fluventic Ustochrepts. Ustochrepts like the Typic except for a.

Lithic Ustochrepts. Ustochrepts like the Typic except for b.

Lithic-Vertic Ustochrepts. Ustochrepts like the Typic except for b and d.

Rendollic Ustochrepts. Ustochrepts like the Typic except for c.

Vertic Ustochrepts. Ustochrepts like the Typic except for d with or without a.

Xerochrepts. Ochrepts that

1. are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact, whichever is shallower or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches).

2. have a mean annual soil temperature of 8°C (47°F) or more but less than 22°C (72°F), or of less than 8°C (47°F) if mean summer soil temperature is 15°C (59°F) or more and there is no O horizon, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) depth, or at a lithic or a paralithic contact shallower than 50 cm (20 inches) that differ by 5°C (9°F) or more;

3. lack a fragipan and lack a duripan with its upper boundary within 1 m (40 inches) of the soil surface.

Lithic Ustropepts. Ustropepts like the Typic except for d.

Lithic Oxic Ustropepts. Ustropepts like the Typic except for d and e, and the CEC is < 24 meq per 100 g clay or 2.5 x 15-bar water, whichever value is higher.

Lithic Vertic Ustropepts. Ustropepts like the Typic except for d and f with or without c.

Oxic Ustropepts. Ustropepts like the Typic except for e and the CEC is < 24 meq per 100 g clay or 2.5 X 15-bar water, whichever value is the higher.

Vertic Ustropepts. Ustropepts like the Typic except for f with or without b or c, or both.

Umbrepts. Inceptisols that

1. have an exchange complex that is dominated by crystalline aluminosilicate clay minerals and have less than 60 percent vitric volcanic ash, cinders, or other vitric pyroclastic materials in the silt, sand, and gravel fractions;

2. are not saturated with water at any season or lack the characteristics associated with wetness defined for Aquepts;

3. have 5°C (9°F) or more difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower;

4. lack a plaggen epipedon;

5. have one of the following characteristics:

   a. if the mean annual soil temperature is 8°C (47°F) or more, have either an umbric or anthropic epipedon that is more than 25 cm (10 inches) thick or a mollic epipedon that is more than 25 cm (10 inches) thick if it is underlain by a cambic horizon with base saturation of less than 50 percent (by NH_4OAc) in some part;

   b. if the mean annual soil temperature is less than 8°C (47°F), have either an umbric epipedon, or a mollic epipedon if the mollic epipedon is underlain by a cambic horizon that has base saturation of less than 50 percent (by NH_4OAc) in some part.

Anthrumbrepts. Umbrepts that

1. have an anthropic epipedon;

2. have no fragipan.

(Subgroups have not been developed.)

Cryumbrepts. Umbrepts that

1. have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon;

2. lack a fragipan;

3. lack an anthropic epipedon.

Typic Cryumbrepts. Cryumbrepts that

   a. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;

   b. have a cambic horizon;

   c. have no lithic contact within 50 cm (20 inches) of the surface;

ARIDISOLS: ORDER 4

Mineral soils that have no oxic or spodic horizons but have an ochric epipedon and one or more of the following combinations of properties:

1. have no argillic or natric horizon but within 1 m (40 inches) of the surface have one or more of the following horizons: calcic, petrocalcic, gypsic, cambic, or duripan; and either are usually dry between 18 and 50 cm (7 and 20 inches) depth or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in some subhorizon above a lithic or a paralithic contact shallower than 18 cm (7 inches) or have a conductivity of the saturation extract that is 2 mmho per cm or greater at 25°C in some part above whichever of the following depths is least: a lithic or paralithic contact, 1.25 m (50 inches) if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey; or with increase in depth within the C horizon but above the depths for the different particle-size classes specified above there is an increase in saturation with Na plus K in some part;

2. have no argillic or natric horizon but have a salic horizon within 75 cm (30 inches) of the surface and are saturated with water within 1 m (40 inches) of the surface for one month or more;

3. have a surface horizon that is not both hard and massive when dry; an argillic or natric horizon; and are usually dry in most years in all parts of the soil between 18 and 50 cm (7 and 20 inches) or a lithic or paralithic contact shallower than 50 cm (20 inches) or in some subhorizon above a lithic or a paralithic contact shallower than 18 cm (7 inches);

4. after the upper 18 cm (7 inches) are mixed, have a clay content of less than 30 percent in some horizon within a depth of 1 m (40 inches) if there are cracks at least 1 cm wide at a depth of 50 cm at some period in most years and:
   a. there is gilgai, or
   b. at some depth between 25 cm and 1 m (10 and 40 inches), there are slickensides close enough to intersect or there are wedge-shaped or parallelepiped natural structural aggregates with their long axes tilted 10 to 60 degrees from the horizontal.

Argids. Aridisols that have an argillic or natric horizon.

Durargids. Argids that

1. have a duripan below an argillic horizon or below a prismatic or blocky natric horizon and the upper boundary of the duripan is within 1 m (40 inches) of the soil surface;

2. have no petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the soil surface.

Typic Durargids. Durargids that

a. have none of the following characteristics within 1 m (40 inches) of the surface:

   (1) dominant chromas of 1 or less throughout and hues as yellow or yellower than 2.5Y in some portion;

   (2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;

   (3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable sodium from the upper 25 cm (10 inches) to the underlying layer;

b. have a platy or massive duripan that is indurated in some subhorizon;

c. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4. (See figure A, page 120)

Typic Durargids--Cont.

d. have no argillic horizon or prismatic or blocky natric horizon that has both 35 percent or more clay in some part and either:

(1) an increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon, or

(2) an increase of 10 percent or more clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon.

Aquic Durargids. Durargids like the Typic except for a or a and c.

Haplic Durargids. Durargids like the Typic except for b.

Haplic Mollic Durargids. Durargids like the Typic except for b and c and the duripan is brittle and has 20 percent or more by volume of durinodes in some subhorizon.

Mollic Durargids. Durargids like the Typic except for c.

Mollic Paleic Durargids. Durargids like the Typic except for c and d.

Natrargids. Argids that

a. have no duripan within 1 m (40 inches) of the surface or columnar natric horizon;

b. have an argillic horizon or prismatic or blocky natric horizon that has one or both of the following:

a. less than 35 percent clay in all subhorizons;

b. an increase of less than 15 percent clay (absolute) within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon, or an increase of less than 10 percent clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon;

c. have a calcic horizon that has its upper boundary within 1 m (40 inches) of the surface.

Typic Haplargids. Haplargids that

a. have one of the following characteristics within 1 m (40 inches) of the surface:

(1) dominant chroma of 1 or less throughout and hues as yellow or redder than 2.5Y in some portion;

(2) dominant chroma of 2 or less accompanied by mottles not due to segregated lime;

(3) dominant chroma of 2 or less accompanied by a decrease in the percentage of exchangeable Mg from the upper 25 cm (10 inches) to the underlying layer;

b. have textures finer than loamy fine sand in some subhorizon within the upper 50 cm (20 inches);

c. have no brittle horizon that is 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface that contains some opal coatings or some (less than 20 percent by volume) durinodes;

d. have no lithic contact within 50 cm (20 inches) of the surface;

e. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)

Aquic Natrargids. Natrargids like the Typic except for a or a and e.

Aquic Duric Natrargids. Natrargids like the Typic except for a and b.

Duric Natrargids. Natrargids like the Typic except for b.

Duric Mollic Natrargids. Natrargids like the Typic except for b and e.

Glossic Mollic Natrargids. Natrargids like the Typic except for c and e.

Lithic Natrargids. Natrargids like the Typic except for d.

Lithic Mollic Natrargids. Natrargids like the Typic except for d and e.

Mollic Natrargids. Natrargids like the Typic except for e.

Vertic Natrargids. Natrargids like the Typic except for f or f and e.

Paleargids. Argids that

1. have either a petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the soil surface or that have an argillic horizon or prismatic or blocky natric horizon that has both 35 percent or more clay in some part, and either:

   a. an increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon; or

   b. an increase of 10 percent or more clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon;

2. have no duripan that has its upper boundary within 1 m (40 inches) of the surface.

Typic Paleargids. Paleargids that

   a. have no brittle horizon that is 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface and that contains some opal coatings or some (less than 20 percent by volume) durinodes;

   b. have no lithic contact within 50 cm (20 inches) of the surface;

   c. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Of, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)

   d. have no petrocalcic horizon with its upper boundary within 1 m (40 inches) of the surface;

   e. have no columnar natric horizon;

   f. have either:

      (1) an increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon, or

      (2) an increase of 10 percent or more clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon.

Duric Paleargids. Paleargids like the Typic except for a.

Lithic Paleargids. Paleargids like the Typic except for b.

Ustollic Camborthids. Camborthids like the Typic except for d and e and the soils are not continuously dry in all parts between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) in more than 7 out of 10 years for as long as 60 days if the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Xerertic Camborthids. Camborthids like the Typic except for e and f with or without b or d or both, and have (a) cracks that open and close once each year and remain open for 60 consecutive days or more during the year in more than 7 out of 10 years, and (b) mean annual soil temperatures less than 22°C (72°F) and mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more.

Xerollic Camborthids. Camborthids like the Typic except for d and e and the soils are continuously dry in all parts between 18 and 50 cm (7 and 20 inches) or a lithic or paralithic contact shallower than 50 cm (20 inches) in more than 7 out of 10 years for 60 days or more and the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Durorthids. Orthids that

1. have a duripan that has its upper boundary within 1 m (40 inches) of the surface and are with or without a cambic horizon;

2. have no petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the surface.

Typic Durorthids. Durorthids that

a. have none of the following characteristics within 1 m (40 inches) of the surface:

   (1) dominant chromas of 1 or less throughout and hues as yellow or yellower than 2.5Y in some portion;

   (2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;

   (3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable sodium from the upper 25 cm (10 inches) to the underlying subhorizon;

b. have a platy or massive duripan that is indurated in some subhorizon;

c. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)

d. are usually dry in all parts of the soil between depths of 18 and 50 cm (7 and 20 inches) or to a lithic or a paralithic contact shallower than 50 cm (20 inches).

Aquic Durorthids. Durorthids like the Typic except for a with or without c or d, of both.

Aquentic Durorthids. Durorthids like the Typic except for a and b with or without c or d, or both.

Durixerollic Durorthids. Durorthids like the Typic except for c and d and the soils are continuously dry in all parts between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for 60 days or more and the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Durustollic Durorthids. Durorthids like the Typic except for c and d and the soils are not continuously dry in all parts between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as long as 60 days if the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Entic Durorthids. Durorthids like the Typic except for b.

Entic Mollic Durorthids. Durorthids like the Typic except for b and c.

Haploxerollic Durorthids. Durorthids like the Typic except for b, c, and d and the soils are continuously dry in all parts between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for 60 days or more and the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Haplustollic Durorthids. Durorthids like the Typic except for b, c, and d and the soils are not continuously dry in all parts between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as long as 60 days if the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Mollic Durorthids. Durorthids like the Typic except for c.

Paleorthids. Orthids that

1. have a petrocalcic horizon that has its upper boundary withint 1 m (40 inches) of the soil surface;

2. have no duripan that has its upper boundary within 1 m (40 inches) of the soil surface;

3. have no salic horizon within 75 cm (30 inches) of the surface if saturated with water (i.e. within the capillary fringe) within 1 m (40 inches) of the surface for 1 month or more

Typic Paleorthids. Paleorthids that

a. have none of the following characteristics within 1 m (40 inches) of the surface:

(1) dominant chromas of 1 or less throughout and hues as yellow or yellower than 2.5Y in some portion;

(2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;

(3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable Na from the upper 25 cm (10 inches) to the underlying layer;

b. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have intermediate carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)

c. are usually dry in all parts of the soil between depths of 18 and 50 cm (7 and 20 inches) or to a lithic or a paralithic contact shallower than 50 cm (20 inches).

Aquic Paleorthids. Paleorthids like the Typic except for a or a and c.

Mollic Paleorthids. Paleorthids like the Typic except for b.

Ustollic Paleorthids. Paleorthids like the Typic except for b and c and are not continuously dry in all parts between 18 and 50 cm (7 and 20 inches) or the upper boundary of a petrocalcic horizon shallower than 20 cm (20 inches) or in some part of the soil above a petrocalcic horizon with an upper boundary shallower than 18 cm (7 inches) in more than 7 out of 10 years for as long as 60 days if the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more

Aquolls--Cont.

b. (1) distinct or prominent mottles in the lower mollic epipedon; or

(2) base colors immediately below the mollic epipedon that have one or more of:

(a) values of 4 and chromas of 2 accompanied by some mottles with values of 4 or more and chromas of less than 2;

(b) values of 4 and chromas of less than 2;

(c) values of 5 or more and chromas of 2 or less accompanied by mottles with high chromas;

4. a calcic horizon that has an upper boundary within 40 cm (16 inches) of the surface.

Argiaquolls. Aquolls that

1. have an argillic horizon but have no natric horizon or duripan;

2. have mean annual soil temperature of 8°C (47°F) or higher, or mean summer soil temperature at 50 cm (20 inches) of 15°C (59°F) or higher if the soil is drained and cultivated, or 8°C (47°F) or higher if the soil is drained and has an O horizon or a histic epipedon, or 6°C (43°F) or higher if the soil is undrained and has a histic epipedon or an O horizon.

Typic Argiaquolls. Argiaquolls that

a. have no argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm (3 inches) from the upper boundary;

b. have a mollic epipedon with chromas of 2 or less;

c. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;

d. have no disseminated carbonates below 18 cm (7 inches) in the lower part of the mollic epipedon and in the upper part of the argillic horizon;

e. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Abruptic Argiaquolls. Argiaquolls like the Typic except for a.

Aeric Argiaquolls. Argiaquolls like the Typic except for b.

Arenic Argiaquolls. Argiaquolls like the Typic except for c and have a sandy epipedon between 50 cm and 1 m (20 and 40 inches) thick.

Calcic Argiaquolls. Argiaquolls like the Typic except for d.

Grossarenic Argiaquolls. Argiaquolls like the Typic except for c and have a sandy epipedon more than 1 m (40 inches) thick.

Vertic Argiaquolls. Argiaquolls like the Typic except for e.

Argiborolls. Borolls that

1. have an argillic horizon, but have no cambic horizon overlying the argillic horizon and separated from it by an albic horizon;

2. have no natric horizon;

3. have the upper boundary of the argillic horizon within 60 cm (24 inches) of the surface*or have textures coarser than loamy very fine sand in all subhorizons above the argillic horizon;

4. have mean summer soil temperatures at 50 cm (20 inches) of 15°C (59°F) or more if without an O horizon, or of 8°C (47°F) or more if with an O horizon.

Typic Argiborolls. Argiborolls that

a. have no argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm (3 inches) from the upper boundary;

b. have no albic horizon underlying the mollic epipedon;

c. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

d. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;

e. have no albic horizon that tongues or interfingers into at least the upper part of the argillic horizon;

f. have base saturation (by NH_4OAc) of more than 60 percent in all subhorizons of the argillic horizon;

g. have no lithic contact within 50 cm (20 inches) of the surface;

h. have a mollic epipedon less than 40 cm (16 inches) thick;

i. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Abruptic Argiborolls. Argiborolls like the Typic except for a.

Albic Argiborolls. Argiborolls like the Typic except for a, b and d or a and d.

Andic Argiborolls. Argiborolls like the Typic except for c with or without h.

Aquic Argiborolls. Argiborolls like the Typic except for d.

Boralfic Argiborolls. Argiborolls like the Typic except for e.

Glossoboralfic Argiborolls. Argiborolls like the Typic except for e and f.

If there is a surface mantle that has more than 60 percent vitric volcanic ash, cinders or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral surface.

Typic Cryoborolls--Cont.

c. have no distinct or prominent mottles due to segregation of iron or manganese within 1 m (40 inches) of the surface;

d. have no calcic horizon within or immediately underlying the mollic epipedon;

e. have a mollic epipedon less than 40 cm (16 inches) thick;

g. have no lithic contact with its upper boundary within 50 cm (20 inches) of the surface;

h. have a mean annual soil temperature of more than 0°C (32°F);

i. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;

j. have no albic horizon immediately below the mollic epipedon.

Abruptic Cryoborolls. Cryoborolls like the Typic except for a and j and have an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm (3 inches) from the upper boundary.

Andic Cryoborolls. Cryoborolls like the Typic except for b or b and e.

Andic Argic Cryoborolls. Cryoborolls like the Typic except for a and b with or without e.

Aquic Cryoborolls. Cryoborolls like the Typic except for c.

Argiaquic Cryoborolls. Cryoborolls like the Typic except for a and c.

Argic Cryoborolls. Cryoborolls like the Typic except for a.

Argic Lithic Cryoborolls. Cryoborolls like the Typic except for a and g.

Argic Pachic Cryoborolls. Cryoborolls like the Typic except for a and e with or without c.

Argic Vertic Cryoborolls. Cryoborolls like the Typic except for a and i with or without e.

Boralfic Cryoborolls. Cryoborolls like the Typic except for a with or without e or or j, or both, and have an albic horizon that tongues or interfingers into at least the upper part of the argillic horizon.

Boralfic Lithic Cryoborolls. Cryoborolls like the Typic except for a and g with or without e or j, or both, and have an albic horizon that tongues or interfingers into at least the upper part of the argillic horizon.

Calcic Cryoborolls. Cryoborolls like the Typic except for d.

Calcic Pachic Cryoborolls. Cryoborolls like the Typic except for d and e with or without a or c, or both.

Cryoborolls--Cont.

Lithic Cryoborolls. Cryoborolls like the Typic except for g.

Natric Cryoborolls. Cryoborolls like the Typic except for a with or without j and have more than 15 percent saturation with exchangeable sodium in the major part of the argillic horizon.

Pachic Cryoborolls. Cryoborolls like the Typic except for e with or without a or c, or both.

Pergelic Cryoborolls. Cryoborolls like the Typic except for h.

Vertic Cryoborolls. Cryoborolls like the Typic except for i with or without e.

Haploborolls. Borolls that

1. have soil temperatures higher than those of Cryoborolls;
2. have no argillic or natric horizon unless it underlies a cambic horizon and is separated from the cambic horizon by an albic horizon;
3. have a transition between the mollic epipedon and the underlying horizon that has less than 25 percent by volume of worm holes, worm casts or filled animal burrows.

Typic Haploborolls. Haploborolls that

a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;

b. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;

c. have a mollic epipedon less than 40 cm (16 inches) thick;

d. have a cambic horizon or have a mollic epipedon that is between 25 and 40 cm (10 and 16 inches) thick and has one or more of the following in the lower portion:

(1) moderate or strong prismatic, blocky, or subangular blocky structure;

(2) higher chroma than the upper portion;

(3) higher value than the upper portion;

(4) redder hue than the upper portion;

e. have a regular decrease in organic matter content with depth and a level of 0.5 percent (0.29 percent organic carbon) or less within 1.25 m (50 inches) of the surface;

f. have no lithic contact with its upper boundary within 50 cm (20 inches) of the surface;

g. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

Typic Rendolls--Cont.

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Rendolls. Rendolls like the Typic except for a.

Cryic Rendolls. Rendolls like the Typic except for b.

Entic Rendolls. Rendolls like the Typic except that the dry color value of the epipedon is 6 or more after the surface 18 cm (7 inches) have been mixed.

Eutrochreptic Rendolls. Rendolls like the Typic except for c and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more, and no subhorizon below a depth of 5 cm (2 inches) is dry for as much as 90 cumulative days in most years.

Eutropeptic Rendolls. Rendolls like the Typic except for c and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by less than 5°C (9°F), and no subhorizon below a depth of 5 cm (2 inches) is dry for as much as 90 cumulative days in most years.

Haplustic Rendolls. Rendolls like the Typic except for c and some subhorizon below a depth of 5 cm (2 inches) is dry for 90 cumulative days or more in most years, and the mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a paralithic contact, whichever is shallower, differ by more than 5°C (9°F).

Histic Rendolls. Rendolls like the Typic except for b and d. (None in U. S.)

Lithic Rendolls. Rendolls like the Typic except for e.

Vertic Rendolls. Rendolls like the Typic except for f.

Udolls. Udolls are Mollisols that

1. have either:

   a. mean annual soil temperatures of 8°C (47°F) or more; or

   b. have a moist chroma of more than 1.5 in some part of the upper 15 cm (6 inches) of the mollic epipedon and have mean summer soil temperatures at 50 cm (20 inches) depth or a lithic or paralithic contact, whichever is shallower, of 15°C (59°F) or more if without an O horizon, or 8°C (47°F) or more if with an O horizon.

2. have no albic horizon with characteristics associated with wetness, namely, mottles, iron-manganese concretions, or both;

3. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aquolls;

4. have no calcareous horizon that immediately underlies the mollic epipedon at depths of less than 50 cm (20 inches) and that has more than 40 percent calcium carbonate equivalent;

5. are continuously moist in any cambic or argillic horizon, or the soil is not dry in more than 7 out of 10 years for as much as 60 consecutive days in all horizons between 18 and 50 cm (7 and 20 inches) and it is not dry for as much as 90 cumulative days in any horizon between these depths in most years.

6. have no calcic horizon and have no concentration of soft powdery lime in spheroidal forms, as coatings, on peds, or disseminated in clay-size particles within 1.5 m (60 inches) of the soil surface or within 50 cm (20 inches) below the base of any cambic or argillic horizon;

7. if there is a lithic or paralithic contact within 50 cm (20 inches), have base saturation (by NH_4OAc) of less than 80 percent in some or all subhorizons.

Udolls-Cont.

Argiudolls. Udolls that have an argillic horizon that has clay distribution such that the clay decreases by 20 percent or more of the maximum clay content within 1.5 m (60 inches) of the surface if:

1. hues are redder than 10YR with chromas of more than 4 dominant in the matrix in at least the lower part of the argillic horizon; or

2. there are many coarse mottles that have hues redder than 7.5YR or chromas of more than 5.

Typic Argiudolls. Argiudolls that

a. have colors as follows:

(1) immediately below the mollic epipedon (within 15 cm (6 inches) of the lower boundary) have hues of 10YR or redder and chromas of 3 or higher, and no mottles have chromas of 2 or less in values of 4 or more; and

(2) no matrix colors in hues 10YR or redder are as dark or darker than a value 2.5 with chroma of 2 or less to a depth of 50 cm (20 inches) if accompanied by faint mottling within that depth; and

(3) no matrix colors in hues 2.5Y or yellower are as dark or darker than a value of 4 with chroma of 3 or less to a depth of 50 cm (20 inches) if accompanied by faint mottling within 20 inches; and

(4) no mottles are present within 40 cm (16 inches) below the surface;

b. have no albic horizon that tongues into at least the upper part of the argillic horizon;

c. have no lithic contact within 50 cm (20 inches) of the surface;

d. have textures finer than loamy fine sand in the argillic horizon, or the argillic horizon does not consist entirely of lamellae with a combined thickness of less than 15 cm (6 inches);

e. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Argiudolls. Argiudolls that the Typic except for a.

Glossoboralfic Argiudolls. Argiudolls like the Typic except for b.

Lithic Argiudolls. Argiudolls like the Typic except for c.

Psammentic Argiudolls. Argiudolls like the Typic except for d.

Vertic Argiudolls. Argiudolls like the Typic except for e.

Hapludolls. Udolls that

1. have no argillic horizon;

2. have a transition between the mollic epipedon and the underlying horizon that has less than 25 percent by volume of worm holes, worm casts or filled animal burrows.

Argiustolls--Cont.

(1) hues are redder than 10YR and chromas are more than 4 in the matrix, or

(2) there are common coarse mottles with hues of 7.5YR or redder or chromas of more than 5; and

b. a sandy or loamy particle-size class in the upper part or an increase of less than 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;

2. have no duripan with its upper boundary within 1 m (40 inches) of the surface;

3. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface;

4. have no natric horizon.

Typic Argiustolls. Argiustolls that

a. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;

b. have no brittle horizon 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface that contains some opal coatings or some (less than 20 percent by volume) durinodes;

c. have no lithic contact within 50 cm (20 inches) of the surface;

d. have less than 15 percent saturation with exchangeable sodium in the major part of the argillic horizon;

e. have a mollic epipedon less than 50 cm (20 inches) thick;

f. have either or both of:

(1) a calcic horizon or soft powdery secondary lime within a depth of 1 m (40 inches) if the particle-size class is sandy, 70 cm (28 inches) if loamy, and 60 cm (24 inches) if clayey;

(2) increasing saturation with Na plus K with increasing depth within 1.25 m (50 inches) if the particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey;

g. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Argiustolls. Argiustolls like the Typic except for a or a and f.

Duric Argiustolls. Argiustolls like the Typic except for b.

Lithic Argiustolls. Argiustolls like the Typic except for c.

Lithic Udic Argiustolls. Argiustolls like the Typic except for c and f.

Natric Argiustolls. Argiustolls like the Typic except for d.

Pachic Argiustolls Argiustolls like the Typic except for e with or without a or f, or both.

Typic Durustolls. Durustolls that

a. have no mottles with chromas of 2 or less above the duripan;

b. have a platy, massive, or prismatic duripan that is indurated in some subhorizon, or that is indurated and coated with opal or opal and sesquioxides in more than half of the surface of the upper boundary of the duripan;

c. have an argillic horizon above the duripan.

Aquic Durustolls. Durustolls like the Typic except for a.

Argic Durustolls. Durustolls like the Typic except for b.

Entic Durustolls. Durustolls like the Typic except for b and c.

Haplic Durustolls. Durustolls like the Typic except for c.

Haplustolls. Ustolls that

1. have no argillic or natric horizon unless it is a buried horizon;

2. have no duripan with its upper boundary within 1 m (40 inches) of the surface;

3. have no calcic or gypsic horizon with its upper boundary within 1 m (40 inches) of the surface unless some part of some horizon overlying the calcic or gypsic horizon is free of carbonates after mixing the upper 18 cm (7 inches) and has a texture of loamy very fine sand or finer;

4. have a transition between the mollic epipedon and the underlying horizon that has less than 25 percent by volume of worm holes, worm casts or filled animal burrows.

5. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface.

Typic Haplustolls. Haplustolls that

a. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface or are not continuously saturated with water for 90 days or more within 1 m (40 inches) of the surface;

b. have a mollic epipedon less than 50 cm (20 inches) thick;

c. have no brittle horizon 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface that contains some opal coatings or some (less than 20 percent by volume) durinodes;

d. have a mollic epipedon overlying a cambic horizon; or have a mollic epipedon that is noncalcareous, at least in the upper half, and its lower portion has one or more of the following:

(1) moderate or strong prismatic, blocky, or subangular blocky structure;

(2) higher chroma than in the upper portion;

(3) higher value than in the upper portion;

(4) redder hues than in the upper portion;

e. have a regular decrease in organic matter content with depth to a level of 0.5 percent (0.29 percent organic carbon) or less within 1.25 m (50 inches) of the surface;

f. have no lithic contact within 50 cm (20 inches) of the surface;

g. have no salic horizon within 75 cm (30 inches) of the surface;

Haplustolls--Cont.

Udic Haplustolls. Haplustolls like the Typic except for i.

Udorthentic Haplustolls. Haplustolls like the Typic except for d and i.

Vermic Haplustolls. Haplustolls like the Typic except for b and d and have a mollic epipedon and either or both a cambic horizon, or a horizon with secondary carbonates that, bwlow any Ap, has 50 percent or more by volume of worm holes, worm casts or filled animal burrows.

Vertic Haplustolls. Haplustolls like the Typic except for h, with or without all or any of b, d, or e.

Natrustolls. Ustolls that

1. have a natric horizon;

2. have no petrocalcic horizon with an upper boundary within 1.5 m (60 inches) of the surface;

3. have no duripan with an upper boundary within 1 m (40 inches) of the surface.

Typic Natrustolls. Natrustolls that

a. have none of the following characteristics within 1 m (40 inches) of the surface:

(1) dominant chromas of 1 or less throughout and hues as yellow or yellower than 2.5Y in some portion;

(2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;

(3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable sodium from the upper 25 cm (10 inches) layer to the underlying layer;

b. have no brittle horizon 15 cm (6 inches) or more thick that is within 1 m (40 inches) of the surface and that contains some opal coatings or some (less than 20 percent by volume) durinodes;

c. have no tonguing or interfingering of an albic horizon more than 2.5 cm (1 inch) into a natric horizon.

d. have a natric horizon that has a lower boundary deeper than 40 cm (16 inches) from the surface;

e. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Natrustolls. Natrustolls like the Typic except for a.

Aquic Duric Natrustolls. Natrustolls like the Typic except for a and b.

Duric Natrustolls. Natrustolls like the Typic except for b.

Natrustolls--Cont.

Glossic Natrustolls. Natrustolls like the Typic except for c.

Leptic Natrustolls. Natrustolls like the Typic except for d.

Vertic Natrustolls. Natrustolls like the Typic except for e.

Paleustolls. Ustolls that

1. have a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface, or an argillic horizon that has either or both:

   a. a vertical clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface, and one or both of:

      (1) hues redder than 10YR and chromas of more than 4 in the matrix,

      (2) common coarse mottles with hues of 7.5YR or redder or chromas of more than 5; or

   b. a particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;

2. have no duripan that has an upper boundary within 1 m (40 inches) of the soil surface;

3. have no natric horizon.

Typic Paleustolls. Paleustolls that

   a. have no increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary of the argillic horizon;

   b. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;

   c. have a mollic epipedon less than 50 cm (20 inches) thick;

   d. have no petrocalcic horizon within 1.5 m (60 inches) of the surface;

   e. have either or both of:

      (1) a calcic horizon, or soft powdery secondary lime within a depth of 1 m (40 inches) if the particle-size class is sandy, 70 cm (28 inches) if loamy, and 60 cm (24 inches) if clayey, or

      (2) increasing saturation with Na plus K with increasing depth within 1.25 m (50 inches) if the particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey;

   f. lack the following combination of characteristics:

      (1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

      (2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

      (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Abruptic Paleustolls. Paleustolls like the Typic except for a.

Paleustolls-Cont.

Abruptic Aquic Paleustolls. Paleustolls like the Typic except for a and b.

Abruptic Udic Paleustolls. Paleustolls like the Typic except for a and e.

Aquic Paleustolls. Paleustolls like the Typic except for b with or without e.

Pachic Paleustolls. Paleustolls like the Typic except for c with or without b or e, or both.

Petrocalcic Paleustolls. Paleustolls like the Typic except for d with or without a.

Udertic Paleustolls. Paleustolls like the Typic except for e and f or b, e and f.

Udic Paleustolls. Paleustolls like the Typic except for e.

Vertic Paleustolls. Paleustolls like the Typic except for f or f and b.

Vermustolls. Ustolls that

1. have no argillic or natric horizon;

2. have a mollic epipedon, below any Ap, that is 50 percent or more by volume of worm holes and worm casts or filled animal burrows, and that either rests on a lithic contact or has a transition to the underlying horizon in which 25 percent or more of the material is discrete worm casts or filled animal burrows from the mollic epipedon and the underlying horizon.

Typic Vermustolls. Vermustolls that

a. have a mollic epipedon 50 cm (20 inches) of more thick but less than 75 cm (30 inches) thick;

b. have no cambic horizon;

c. have a mollic epipedon, below any Ap, that has a transition to the underlying horizon in which 50 percent or more of the volume is worm holes and worm casts or filled animal burrows;

d. have no lithic contact within 50 cm (20 inches) of the surface;

e. have a mollic epipedon with granular structure composed almost entirely below any Ap of worm holes, worm casts or filled animal burrows;

f. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface.

Entic Vermustolls. Vermustolls like the Typic except for a and the epipedon is less than 50 cm (20 inches) thick.

Haplic Vermustolls. Vermustolls like the Typic except for b and c with or without a and the epipedon is less than 75 cm (30 inches) thick.

Lithic Vermustolls. Vermustolls like the Typic except for d and a with or without b or c, or both, and the epipedon is less than 75 cm (30 inches) thick.

Pachic Vermustolls. Vermustolls like the Typic except for a and the epipedon is 75 cm (30 inches) or more thick.

Xerolls. Xerolls are Mollisols that

1. have either:

a. mean annual soil temperatures of 8°C (47°F) or more, or

b. have a moist chroma of more than 1.5 in some part of the upper 15 cm (6 inches) of the mollic epipedon and have mean summer soil temperatures at 50 cm (20 inches) depth or a lithic or paralithic contact, whichever is shallower, of 15°C (59°F) or more if without an O horizon, or 8°C (47°F) or more if with an O horizon;

Typic Argixerolls--Cont.

h. have base saturation of more than 75 percent throughout the argillic horizon or the upper 50 cm (20 inches);

i. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Argixerolls. Argixerolls like the Typic except for a.

Aquic Calcic Argixerolls. Argixerolls like the Typic except for a and c.

Aquultic Argixerolls. Argixerolls like the Typic except for a and h.

Boralfic Argixerolls. Argixerolls like the Typic except for b with or without c or h, or both.

Calcic Argixerolls. Argixerolls like the Typic except for c.

Calcic Lithic Argixerolls. Argixerolls like the Typic except for c and e.

Calcic Pachic Argixerolls. Argixerolls like the Typic except for c and g with or without a.

Duric Argizerolls. Argixerolls like the Typic except for d with or without c.

Glossaqualfic Argixerolls. Argixerolls like the Typic except for a and b with or without c or h, or both.

Lithic Argixerolls. Argixerolls like the Typic except for e.

Lithic Ultic Argixerolls. Argixerolls like the Typic except for e and h.

Natric Argixerolls. Argixerolls like the Typic except for f with or without c.

Pachic Argixerolls. Argixerolls like the Typic except for g with or without a.

Pachic Ultic Argixerolls. Argixerolls like the Typic except for g and h with or without a.

Ultic Argixerolls. Argixerolls like the Typic except for h.

Vertic Argixerolls. Argixerolls like the Typic except for i with or without c.

Calcixerolls. Xerolls that

1. have a calcic, petrocalcic, or gypsic horizon with an upper boundary within 1.5 m (60 inches) of the soil surface; and

2. are calcareous in all parts of all horizons above the calcic, petrocalcic, or gypsic horizons after the upper 18 cm (7 inches) have been mixed unless textures are coarser than loamy very fine sand; and

3. have no natric horizon or duripan within 1 m (40 inches) of the soil surface.

(Calcixerolls do not occur in the U. S. The depth limits suggested for the calcic, petrocalcic, and gypsic horizons are tentative.)

Haploxerolls--Cont.

3. have no calcic or gypsic horizon with its upper boundary within 1.5 m (60 inches) of the surface unless some part of some horizon overlying the calcic or gypsic horizon is free of carbonates after mixing the upper 18 cm (7 inches) and has a texture of loamy very fine sand or finer.

Typic Haploxerolls. Haploxerolls that

a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface or are not continuously saturated with water for 90 days or more within 1 m (40 inches) of the surface where undrained;

b. have neither:

(1) a calcic horizon or soft powdery secondary lime within a depth of 1.5 m (60 inches) if the particle-size class is sandy, 1.1 m (43 inches) if loamy, and 90 cm (35 inches) if clayey, or above a lithic contact shallower than these depths; nor

(2) increasing saturation with Na plus K with increasing depth within the depths specified above if without a calcic horizon or soft powdery secondary lime within the depths specified in (1) above;

c. have a mollic epipedon less than 50 cm (20 inches) thick;

d. have no brittle horizon 15 cm (6 inches) or more thick that is within 1 m (40 inches) of the surface and that contains some opal coatings or some (less than 20 percent by volume) durinodes;

e. have a cambic horizon or the lower epipedon meets the requirements of a cambic horizon except for color value, and either the cambic horizon or the lower epipedon is free of carbonates in some part;

f. have a regular decrease in organic matter content with depth to a level of 0.5 percent (0.29 percent organic carbon) or less within 1.25 m (50 inches) of the surface;

g. have no lithic contact within 50 cm (20 inches) of the surface;

h. have base saturation of more than 75 percent throughout the upper 75 cm (30 inches) or above a lithic or a paralithic contact,whichever is shallower;

i. have no mollic epipedon with granular structure that, below any Ap, has 50 percent or more by volume of worm holes, worm casts, or filled animal burrows;

j. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches) and that are at least 30 cm (12 inches) long in some part and that extend upward to the surface or to the base of an Ap horizon, and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Haploxerolls. Haploxerolls like the Typic except for a or a and e.

Aquic Calcic Haploxerolls. Haploxerolls like the Typic except for a and b.

Aquic Fluventic Haploxerolls. Haploxerolls like the Typic except for a and f with or without b or e, or both.

Aquultic Haploxerolls. Haploxerolls like the Typic except for a and h with or without e.

SPODOSOLS: ORDER 6

Spodosols are mineral soils that have a spodic horizon, or a placic horizon cemented by iron that overlies a fragipan and that meets all the requirements of a spodic horizon except thickness.

Aquods. Spodosols that are either saturated with water at some period or artificially drained (if a placic horizon or duripan is present, the soil need not be saturated below the placic horizon or duripan) and that have characteristics associated with wetness, namely, one or more of the following:

1. a histic epipedon;
2. mottling in an albic horizon or in the top of the spodic horizon;
3. a duripan in the albic horizon;
4. if free iron and manganese are lacking, or if the moist color value is less than 4 in the upper part of the spodic horizon, either:
   a. have no coatings of iron oxides on the individual grains of silt and sand in the materials in or immediately below the spodic horizon wherever the moist value is 4 or more and unless an Ap horizon rests directly on the spodic horizon there is a transition between the albic and spodic horizons at least 1 cm in thickness;
   b. have fine or medium mottles of iron or manganese in the materials immediately below the spodic horizon.

Cryaquods. Aquods that have no placic horizon or fragipan but have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of:

1. less than 15°C (59°F) if they are drained and have no O horizon;
2. less than 8°C (47°F) if they are drained and have an O horizon;
3. less than 6°C (43°F) if they are undrained and have an O horizon or a histic epipedon.

Typic Cryaquods. Cryaquods that

a. have no lithic contact within 50 cm (20 inches) of the surface;

b. have a mean annual soil temperature of more than 0°C (32°F);

c. have in 50 percent or more of each pedon, a spodic horizon that lacks sufficient free iron to turn redder on ignition (less than 0.5 percent in the fine earth fraction expressed as Fe);

d. have no mottles above the spodic horizon;

e. have no argillic horizon underlying the spodic horizon;

f. have a continuous spodic horizon that is 10 cm (4 inches) or more thick or that is very firm when moist.

Lithic Cryaquods. Cryaquods like the Typic except for a.

Pergelic Cryaquods. Cryaquods like the Typic except for b.

Sideric Cryaquods. Cryaquods like the Typic except for c and d.

Duraquods. Aquods that have an albic horizon that in at least some subhorizon is strongly enough cemented or indurated that a dry fragment will not slake when immersed in water; have temperatures warmer than those of Cryaquods. (Duraquods are not known to occur in the United States.)

Typic Haplaquods--Cont.

(1) has 4 percent or more of organic matter (2.3 percent carbon) in the upper 2 cm; and that

(2) is continuous or is present in more than 90 percent or each pedon;

e. have less than 5 percent by volume of iron-cemented nodules, 2.5 to 30 cm (1 to 12 inches) in diameter, in any subhorizon of the spodic horizon;

f. have no lithic contact within 50 cm (20 inches) of the mineral soil surface;

g. have no surface horizon more than 30 cm (12 inches) thick that meets all requirements of a plaggen epipedon except thickness;

h. have no histic epipedon.

Aeric Haplaquods. Haplaquods like the Typic except for a.

Alfic Haplaquods. Haplaquods like the Typic except for b, with or without a and d; and have an albic horizon that tongues into the argillic horizon, or have either base saturation of 35 percent or more (by sum of cations) in some part of the argillic horizon, or a mean annual soil temperature less than 8°C (47°F).

Arenic Haplaquods. Haplaquods like the Typic except for a and c.

Entic Haplaquods. Haplaquods like the Typic except for a and d.

Ultic Haplaquods. Haplaquods like the Typic except for a and b; have no albic horizon that tongues into the argillic horizon, and have base saturation (by sum of cations) of less than 35 percent throughout the argillic horizon, and have a mean annual soil temperature of 8°C (47°F) or more.

Placaquods. Aquods that have a placic horizon that rests on a spodic horizon, a fragipan, or an albic horizon that is underlain by a fragipan. There may be a histic epipedon at the surface. The horizons above the placic horizon are saturated with water at some period and have faint to distinct mottles of low chromas.

Typic Placaquods. Placaquods that

a. have a mean annual soil temperature of more than 0°C (32°F);

b. have no histic epipedon.

(Placaquods occur in southern Alaska, but they are rare elsewhere in the United States.)

Sideraquods. Aquods that

1. have soil temperatures warmer than those of Cryaquods and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;

2. have one or both of the following:

a. in 50 percent or more of each pedon, a spodic horizon that contains in all subhorizons sufficient free iron to turn redder on ignition (0.5 percent or more in the fine earth fraction expressed as Fe),

b. an Ap horizon that has a moist value of more than 3 or a moist chroma of more than 2 and that rests directly on a spodic horizon, or an Ap horizon that has 0.7 percent or more free iron (expressed as Fe) in the fine earth fraction;

3. have no fragipan below the spodic horizon;

4. have no duripan or placic horizon above the spodic horizon.

Humods. Spodosols that

1. are never saturated with water, or do not have characteristics associated with wetness as defined for Aquods;

2. have one or both of:

   a. in 50 percent or more of each pedon a spodic horizon with a subhorizon that contains dispersed organic matter and aluminum and that lacks sufficient free iron to turn redder on ignition (less than 0.5 percent in the fine earth fraction expressed as Fe),

   b. an Ap horizon that has a moist value of 3 or less and a moist chroma of 2 or less and that rests directly on a spodic horizon having in its upper part a subhorizon or some tongues possessing one or both of:

      (1) dispersed organic matter and a moist value and moist chroma of 3 or less;

      (2) less than 0.7 percent free iron expressed as Fe.

(Humods probably occur, but have not been studied in the United States; the classification that follows is incomplete.)

Cryohumods. Humods that

1. have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) of either less than 15°C (59°F) if cultivated or without an O horizon or less than 8°C (47°F) if with an O horizon;

2. have no fragipan.

(No subgroup definitions are proposed at this time.)

Fragihumods. Humods that have a fragipan below the spodic horizon.

(No subgroup definitions are proposed at this time.)

Haplohumods. (formerly Normihumods) Humods that

1. have soil temperatures warmer than those of Cryohumods, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C 9°F) or more;

2. have no fragipan.

Typic Haplohumods. Haplohumods that

a. have either:

   (1) a spodic horizon that has 1 percent or more organic matter (0.58 percent carbon) in the matrix of the first 30 cm (12 inches) below the top of the spodic horizon, or

   (2) an upper subhorizon of the spodic horizon that has 5 percent or more organic matter (2.9 percent carbon) in the upper 2 cm and that is continuous or is present in more than 90 percent of the area of each pedon;

b. have less than 5 percent by volume of iron-cemented nodules, 2.5 to 30 cm (1 to 12 inches) in diameter, in any subhorizon of the spodic horizon;

c. have no placic horizon in the spodic horizon;

d. have no argillic horizon;

e. have no surface horizon more than 30 cm (12 inches) thick that meets all the requirements for a plaggen epipedon except thickness.

Entic Haplohumods. Haplohumods like the Typic except for a.

Ferrudalfic Haplohumods. Haplohumods like the Typic except for b.

Aquic Fragiorthods. Fragiorthods like the Typic except for b.

Aquic Entic Fragiorthods. Fragiorthods like the Typic except for b and c.

Cryic Fragiorthods. Fragiorthods like the Typic except for d.

Cryohumic Fragiorthods. Fragiorthods like the Typic except for d and e.

Entic Fragiorthods. Fragiorthods like the Typic except for c, because of low organic matter content.

Humic Fragiorthods. Fragiorthods like the Typic except for e.

Haplorthods. (formerly Normorthods) Orthods that

1. have soil temperatures warmer than those of Cryorthods, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;

2. have no fragipan;

3. have no placic horizon above or in the spodic horizon.

Typic Haplorthods. Haplorthods that

a. have no argillic horizon below the spodic horizon;

b. have a continuous spodic horizon that is very firm or extremely firm when moist (ortstein), or that is more than 10 cm (4 inches) thick and has at least 2 percent organic matter (1.16 percent organic carbon) in the upper 10 cm (4 inches);

c. have no distinct or prominent mottles of approximate spherical shape in the spodic horizon unless the variability in color is associated with differences in consistence in such a manner that the redder or darker portions are extremely firm or very firm;

d. have no chromas of 2 or less with mottles, or chromas of less than 2 without mottles, that are dominant in the matrix within 15 cm (6 inches) of the base of the spodic horizon but within 1 m (40 inches) of the surface of the soil;

e. have no horizon 15 cm (6 inches) or more thick below the spodic horizon but within 1 meter (40 inches) of the surface that has a brittle matrix when wet and contains some durinodes;

f. have no lithic contact within 50 cm (20 inches) of the surface;

g. have no intermittent upper subhorizon that has coatings of dispersed organic matter and that lacks sufficient free iron to turn redder on ignition (less than 0.35 percent in the fine earth fraction expressed as Fe);

h. have less than 10 percent organic matter (5.8 percent organic carbon) in the upper 10 cm (4 inches) of the spodic horizon;

i. have 2 percent or more organic matter (1.16 percent organic carbon) in the Ap horizon if the disturbed layer extends into the upper part of the spodic horizon.

Alfic Haplorthods. Haplorthods like the Typic except for a or a and b and the argillic horizon either contains tongues of an albic horizon, or has base saturation of 35 percent or more in some part, or has a mean annual soil temperature of less than 8°C (47°F).

Aqualfic Haplorthods. Haplorthods like the Typic except for a and c, a and d, or a, c, and d, and the argillic horizon either contains tongues of an albic horizon or has base saturation of 35 percent or more in some part, or has a mean annual soil temperature of less than 8°C (47°F).

Aquic Haplorthods. Haplorthods like the Typic except for c or d, or c and d.

Aquentic Haplorthods. Haplorthods like the Typic except for b and c with or without d.

Duric Haplorthods. Haplorthods like the Typic except for e.

Entic Haplorthods. Haplorthods like the Typic except for b, because of thickness or low organic matter content.

Entic Lithic Haplorthods. Haplorthods like the Typic except for f and b because of thickness or low organic matter content.

Humic Haplorthods. Haplorthods like the Typic except for g or h.

Lithic Haplorthods. Haplorthods like the Typic except for f.

Ultic Haplorthods. Haplorthods like the Typic except for a, or a and b, and the argillic horizon has base saturation throughout of less than 35 percent and has no tongues of an albic horizon, and has a mean annual soil temperature of 8°C (47°F) or more.

Placorthods. Orthods that have a placic horizon above or in the spodic horizon.

(No subgroup definitions are proposed at this time.)

Typic Tropaqualfs--Cont.

(3) moist chromas are 1 or less with or without mottles;

b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;

c. have an A1 horizon less than 15 cm (6 inches) thick if its moist value is darker than 3.5, or an Ap horizon having a moist value of 4 or more, or a dry value of 6 or more when crushed and smoothed.

d. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches) and that are at least 30 cm (12 inches) long in some part and that extend to the base of an Ap or an albic horizon, and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aeric Tropaqualfs. Tropaqualfs like the Typic except for a.
Aeric Mollic Tropaqualfs. Tropaqualfs like the Typic except for a and c.
Mollic Tropaqualfs. Tropaqualfs like the Typic except for c.

Vertic Tropaqualfs. Tropaqualfs like the Typic except for d.

Umbraqualfs. Aqualfs that

1. have an umbric epipedon but have no fragipan or natric horizon or duripan;

2. have no albic horizon that tongues into the argillic horizon and have no abrupt textural change between the albic and argillic horizons;

3. have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more.

Typic Umbraqualfs. Umbraqualfs that

a. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

b. lack in the umbric epipedon and horizons above the argillic, soft discrete nodules that are 2.5 to 30 cm (1 to 12 inches) in diameter that constitute more than 5 percent of the volume, that are cemented by iron, and that are accompanied by an irregular or broken upper boundary of the argillic horizon.

Andic Umbraqualfs. Umbraqualfs like the Typic except for a.

Boralfs. Alfisols that

1. are not saturated with water at any season or lack the characteristics associated with wetness defined for Aqualfs;

Typic Paleboralfs--Cont.

e. have base saturation (by NH_4OAc) of more than 60 percent in all subhorizons of the argillic horizon;

f. have tonguing or interfingering of an albic horizon into the argillic horizon;

g. have an A1 less than 15 cm (6 inches) thick if the moist color value is less than 3.5, or an Ap horizon with a moist value of 4 or more, or a dry color value of 6 or more when crushed and smoothed.

Abruptic Paleboralfs. Paleboralfs like the Typic except for a.

Aquic Paleboralfs. Paleboralfs like the Typic except for c.

Aquic Cryic Paleboralfs. Paleboralfs like the Typic except for c and d.

Cryic Paleboralfs. Paleboralfs like the Typic except for d.

Cryic Glossic Paleboralfs. Paleboralfs like the Typic except for d and e.

Cryic Mollic Paleboralfs. Paleboralfs like the Typic except for d and g.

Glossic Paleboralfs. Paleboralfs like the Typic except for e.

Udalfs. Alfisols that

1. have a mean summer soil temperature at 50 cm (20 inches) or above a lithic or paralithic contact, whichever is shallower, or 15°C (59°F) or more if cultivated or lacking an O horizon, or 8°C (47°F) or more if with an O horizon;

2. are usually moist, and are not dry in most years for as much as 60 consecutive days in all parts or 90 cumulative days in some horizon between 18 and 50 cm (7 and 20 inches) and lack a calcic horizon or a horizon with soft powdery secondary lime in or within 50 cm (20 inches) below the base of the argillic horizon;

3. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aqualfs;

4. lack an albic horizon that is continuous, that has dominant moist and dry chromas of 2 or less in the matrix of some subhorizon, and that tongues or interfingers into an argillic or natric horizon, or have a mean annual soil temperature of 8°C (47°F) or more.

Agrudalfs. Udalfs that have an agric horizon. (These soils are not known in the United States.)

Ferrudalfs. Udalfs that

1. have no agric or natric horizon, or fragipan;

2. have no continuous albic horizon that has dominant chromas of 2 or less in the matrix of some subhorizon above the argillic horizon;

3. have a broken upper boundary of the argillic horizon;

4. have discrete nodules in the argillic horizon that range from 2.5 to 5 cm (1 to 2 inches) up to about 30 cm (12 inches) in diameter; exteriors of nodules are enriched and weakly cemented or indurated with iron and have redder hues or stronger chromas than interiors of nodules;

5. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, that differ by 5°C (9°F) or more.

(Typically textures are sandy and the argillic horizon consists of nodules arranged like broken lamellae. These soils have not been identified in the United States. The nodular, broken argillic horizon has often been confused with mottling.)

Fragiudalfs. Udalfs that

1. have a fragipan;

2. have no agric horizon.

Typic Fragiudalfs. Fragiudalfs that

a. have no mottles with chromas of 2 or less within the upper 25 cm (10 inches) of the argillic horizon;

b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

c. have an argillic horizon above the fragipan;

d. have an Ap horizon with moist color value of 4 or more or with a dry color value of 6 or more, crushed and smoothed; or an A1 horizon with a moist color value of more than 3.5 if thicker than 15 cm (6 inches);

e. have a fragipan that has a brittle matrix in at least 70 percent of the cross section of the most strongly cemented subhorizon;

f. have in the subhorizon directly above the fragipan, ped coatings that have dominant moist chromas of 3 or more; or if ped coatings consist of clean silt and sand grains (skeletans), with chromas of 2 or less, the coatings are less than 1 mm thick;

g. have no albic horizon tonguing into the argillic horizon from above.

Albaquic Fragiudalfs. Fragiudalfs like the Typic except for a, and within 3 inches vertical distance at the top of the argillic horizon, have a clay increase of more than 15 percent of the fine earth fraction.

Aqueptic Fragiudalfs. Fragiudalfs like the Typic except for a and f, with or without c, and between the fragipan and the A1 or Ap, have a horizon with dominant chromas of 3 or more and mottles of 2 or less.

Aquic Fragiudalfs. Fragiudalfs like the Typic except for a.

Dystrandeptic Fragiudalfs. Fragiudalfs like the Typic except for b, c and d and the epipedon meets all requirements for an umbric epipedon except thickness.

Glossic Fragiudalfs. Fragiudalfs like the Typic except for g, with or without f.

Mollic Fragiudalfs. Fragiudalfs like the Typic except for b.

Ochreptic Fragiudalfs. Fragiudalfs like the Typic except for f, with or without c and have a horizon between the fragipan and the A1 or Ap that

(1) is 25 cm (10 inches) or more thick;

(2) has chromas of 3 or more in the matrix;

(3) has no mottles with chromas of 2 or less in the upper 25 cm (10 inches).

Umbreptic Fragiudalfs. Fragiudalfs like the Typic except for c and d and the epipedon meets all requirements for an umbric epipedon except thickness.

Glossudalfs. Udalfs that

1. have an albic horizon (or other eluvial horizon with clean silt or sand grains (skeletans) as ped coatings) that tongues into the argillic horizon;

2. have no discrete nodules 2.5 to 30 cm (1 to 12 inches) in size in the argillic horizon with exteriors enriched, weakly cemented, or indurated with iron;

3. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or a lithic or a paralithic contact that differ by 5°C (9°F) or more;

4. have no natric or agric horizons, and no fragipan.

Typic Hapludalfs--Cont.

e. have no interfingering of an albic horizon into the upper argillic horizon, with the albic horizon surrounding some peds;

f. have no lithic contact within 50 cm (20 inches) of the surface;

g. have an Ap horizon with a moist color value of 4 or more or with a dry color value of 6 or more (crushed and smoothed), or the A1 horizon is less than 15 cm (6 inches) thick if its moist value is lower than 3.5;

h. have exchangeable sodium less than 10 percent of the cation exchange capacity throughout the argillic horizon;

i. have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm (8 inches), and has a texture finer than loamy fine sand;

j. have base saturation (by sum of cations) of more than 60 percent at a depth of 1.25 m (50 inches) below the top of the argillic horizon;

k. lack the following combination of characteristics:

(1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches) and that are at least 30 cm (12 inches) long in some part that extend to the surface or to the base of an Ap horizon; and

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Albaquic Hapludalfs. Hapludalfs like the Typic except for a and c.

Andic Hapludalfs. Hapludalfs like the Typic except for b.

Andic Glossoboric Hapludalfs. Hapludalfs like the Typic except for b and c.

Andic Mollic Hapludalfs. Hapludalfs like the Typic except for b and g.

Andic Mollic Glossoboric Hapludalfs. Hapludalfs like the Typic except for b, e and g.

Aquic Hapludalfs. Hapludalfs like the Typic except for c or c and j.

Aquic Arenic Hapludalfs. Hapludalfs like the Typic except for c and d.

Aquic Lithic Hapludalfs. Hapludalfs like the Typic except for c and f.

Aquollic Hapludalfs. Hapludalfs like the Typic except for c and g.

Arenic Hapludalfs. Hapludalfs like the Typic except for d.

Glossaquic Hapludalfs. Hapludalfs like the Typic except for e and c, or e, c and g.

Glossoboric Hapludalfs. Hapludalfs like the Typic except for e or e and g.

Lithic Hapludalfs. Hapludalfs like the Typic except for f.

Lithic Mollic Hapludalfs. Hapludalfs like the Typic except for f and g.

Mollic Hapludalfs. Hapludalfs like the Typic except for g.

Natraquic Hapludalfs. Hapludalfs like the Typic except for c and h.

Natraboric Hapludalfs. Hapludalfs like the Typic except for h and e.

Natriborollic Hapludalfs. Hapludalfs like the Typic except for g, e and h.

Psammentic Hapludalfs. Hapludalfs like the Typic except for i or d and i.

Typic Tropudalfs. Tropudalfs that

a. have no lithic contact within 50 cm (20 inches) of the surface;

b. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the soil surface providing color is not due to uncoated grains of sand. If color is due to uncoated grains of sand, no mottles with chromas of 2 or less in the upper 12.5 cm (5 inches) of the argillic horizon;

c. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;

d. have no abrupt textural change if there are mottles in the upper 25 cm (10 inches) of the argillic horizon;

e. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;

f. have an Ap horizon with a moist color value of 4 or more or with a dry color value of 6 or more (crushed and smoothed), or the A1 horizon is less than 15 cm (6 inches) thick if its moist value is lower than 3.5;

g. have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm (8 inches), and has a texture finer than loamy fine sand;

h. have base saturation (by sum of cations) of more than 60 percent at a depth of 1.25 m (50 inches) below the top of the argillic horizon;

i. have more than 24 meq. CEC/100g clay (by NH_4OAc) and have a cation retention from NH_4Cl of more than 12 meq/100g clay in the major part of the argillic horizon.

Lithic Tropudalfs. Tropudalfs like the Typic except for a.

Ustalfs. Alfisols that

1. have soil temperatures higher than those of Boralfs;

2. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aqualfs;

3. are not continuously dry in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches) for as long as 60 consecutive days in more than 7 out of 10 years unless the mean annual soil temperature is 22°C (72°F) or higher, or the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth or at a lithic or a paralithic contact, whichever is shallower, differ by less than 5°C (9°F), or both, and have one or more of the following:

   a. dry for 90 cumulative days or more in most years in some subhorizon(s) of the soil between 18 and 50 cm (7 and 20 inches) or above a lithic or a paralithic contact shallower than 50 cm (20 inches),

   b. base saturation (by NH_4OAc) of 80 percent or higher in all parts of the soil above a lithic or a paralithic contact that occurs within 50 cm (20 inches) of the surface,

   c. within 1.5 m (60 inches) of the soil surface or within 50 cm (20 inches) below the base of an argillic horizon, either a calcic horizon or a horizon with concentrations of soft powdery lime in spheroidal forms, as coatings on peds, or disseminated in clay size particles, *

   d. no natric horizon but increasing saturation with Na plus K within 1.25 m (50 inches) of the surface if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey.

* If the lime is disseminated, the horizon(s) in which the lime is concentrated should have more lime than the underlying horizon and should have the maximum percentage of clay-sized lime.

Durustalfs. Ustalfs that have a duripan within 1 m (40 inches) of the surface.

Typic Durustalfs. Durustalfs that

a. have a massive platy or prismatic duripan that is indurated in some subhorizon or has more than half of its upper boundary indurated and coated with opal or opal and sesquioxides;

b. have no mottles with chromas of 2 or less in the argillic horizon;

c. have an argillic but not a natric horizon.

Haplic Durustalfs. Durustalfs like the Typic except for a and have an argillic horizon that has either less than 35 percent clay in all parts or has less than 15 percent clay increase within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon.

Natric Durustalfs. Durustalfs like the Typic except for c.

Haplustalfs. Ustalfs that

1. have an argillic horizon but no natric horizon;

2. have no duripan with its upper boundary within 1 m (40 inches) of the surface;

3. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the surface;

4. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within any subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface;

5. have an argillic horizon that has colors in hues no redder than 5YR, or that has moist values of 4 or more, or dry values more than 1 unit higher than moist values;

6. have an argillic horizon that has:

   a. a clay distribution such that the content of clay decreases from the maximum by more than 20 percent of that maximum within a depth of less than 1.5 m (60 inches) from the surface if:

      (1) hues are redder than 10YR and chromas are more than 4 in the matrix; or

      (2) there are common coarse mottles with hues of 7.5YR or redder or chromas of more than 5; and

   b. a sandy or loamy particle-size class in the upper part or an increase of less than 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent within 2.5 cm (1 inch) at the upper boundary.

Typic Haplustalfs. Haplustalfs that

a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;

b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;

c. have no lithic contact within 50 cm (20 inches) of the surface;

d. have CEC of more than 24 meq/100g clay (by NH_4OAc), and have a cation retention from NH_4Cl of more than 12 meq/100g clay in the major part of the argillic horizon. (See Oxic horizon for definition of cation retention.)

e. have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm (8 inches), is not composed entirely of lamellae, and has a texture finer than loamy fine sand;

Paleustalfs. Ustalfs that

1. have a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the surface or have an argillic horizon that has one or both of:

   a. a vertical clay distribution such that the clay does not decrease from the maximum by as much as 20 percent of that maximum within a depth of 1.5 m (60 inches) from the surface and one or both of:

      (1) hues redder than 10YR and chromas of more than 4 in the matrix,

      (2) common coarse mottles with hues of 7.5YR or redder or chromas of more than 5, or

   b. a particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;

2. have no duripan within 1 m (40 inches) of the surface and no natric horizon;

3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within any subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface;

Typic Paleustalfs. Paleustalfs that

a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the soil surface providing color is not due to uncoated grains of sand. If color is due to uncoated grains of sand, no mottles occur with chromas of 2 or less in the upper 12.5 cm (5 inches) of the argillic horizon;

b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;

c. have less than 5 percent plinthite by volume in all subhorizons within 1.5 m (60 inches) of the soil surface;

d. have either or both of:

   (1) a calcic horizon, or soft powdery secondary lime within a depth of 1 m (40 inches) if particle-size class is sandy, 70 cm (28 inches) if loamy, and 60 cm (24 inches) if clayey, or

   (2) increasing saturation with Na plus K with increasing depth within 1.25 m (50 inches) if the particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey;

e. have an argillic horizon with base saturation (by sum of cations) of 75 percent or more in some part;

f. lack the following combination of characteristics:

   (1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface, or to the base of an Ap horizon, and

   (2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

   (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;

g. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface;

Mollic Palexeralfs. Palexeralfs like the Typic except for c.

Petrocalcic Palexeralfs. Palexeralfs like the Typic except for e, or e and g.

Ultic Palexeralfs. Palexeralfs like the Typic except for f and g, with or without c.

Plinthoxeralfs. Xeralfs that have plinthite that forms a continuous phase or that constitutes more than half of the matrix within some subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface.

(Subgroups not developed)

Rhodoxeralfs. Xeralfs that have an argillic horizon that in all parts has colors in hues redder than 5YR and moist values of less than 4 and dry values no more than 1 unit higher than moist values; and that do not have a natric horizon or a duripan.

Typic Rhodoxeralfs. Rhodoxeralfs that

a. have an argillic horizon more than 15 cm (6 inches) thick and that is continuous in each pedon;

b. have no lithic contact within 50 cm (20 inches) of the surface;

c. have more than 24 meq cation exchange capacity per 100 g clay (by NH_4OAc) and the cation retention from NH_4Cl is more than 12 meq per 100 g clay in the major part of the argillic horizon;

d. have no petrocalcic horizon within 1.5 m (60 inches) of the surface.

Lithic Rhodoxeralfs. Rhodoxeralfs like the Typic except for b.

Oxic Rhodoxeralfs. Rhodoxeralfs like the Typic except for c.

Petrocalcic Rhodoxeralfs. Rhodoxeralfs like the Typic except for d.

ULTISOLS: ORDER 8

Ultisols are mineral soils that

1. have one of the following combinations of characteristics:

   a. have an argillic horizon but have no fragipan and have base saturation (by sum of cations) of less than 35 percent at 1.25 m (50 inches) below the upper boundary of the argillic horizon, or 1.8 m (72 inches) below the soil surface, or above a lithic or a paralithic contact, whichever is shallower, or

   b. have a fragipan that

      (1) meets all of the requirements of an argillic horizon or that has clay skins more than 1 mm thick in some part, and

      (2) has base saturation (by sum of cations) of less than 35 percent at a depth of 75 cm (30 inches) below the upper boundary of the fragipan;

2. have a mean annual soil temperature of 8°C (47°F) or higher, and if mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, differ by 5°C (9°F) or more, have mean summer soil temperatures of 15°C (59°F) or higher if without an O horizon, or of 8°C (47°F) or higher if with an O horizon;

3. have no spodic horizon, and no oxic horizon unless it underlies an argillic horizon;

4. have no plinthite that forms a continuous phase within 30 cm (12 inches) of the surface.

Aquults. Ultisols that are either saturated with water at some season or are artificially drained, and that have characteristics associated with wetness, namely: mottles, iron-manganese concretions larger than 2mm or has moist chromas of 2 or less immediately below any Ap or A1 horizon that has moist values of less than 3.5 when rubbed, and have one of the following:

1. dominant moist chromas of 2 or less in coatings on the surface of peds accompanied by mottles within the peds, or dominant moist chromas of 2 or less in the matrix of the argillic horizon accompanied by mottles of higher chromas (if hues are redder than 10YR because of parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived); or

2. moist chromas of 1 or less on surfaces of peds or in the matrix of the argillic horizon.

Fragiaquults. Aquults that have a fragipan but have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Fragiaquults. Fragiaquults that

a. have an ochric epipedon;

b. have mottles, and chromas of 2 or less in all horizons between the fragipan and the A1 or Ap horizon;

c. have less than 5 percent plinthite in any horizon within 1.5 m (60 inches) of the surface.

Plinthic Fragiaquults. Fragiaquults like the Typic except for c.

Plinthudic Fragiaquults. Fragiaquults like the Typic except for b and c.

Ochraquults. Aquults that

1. have no fragipan;

2. have an ochric epipedon;

3. have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;

Ochraquults--Cont.

4. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in all subhorizons within 1.25 m (50 inches) of the surface.

Typic Ochraquults. Ochraquults that

a. (1) if mottled, have in 60 percent or more of the mass between the A1 or Ap and 75 cm (30 inches) one of the following:

(a) if hues are 2.5Y or redder and moist values are more than 5, moist chromas are 2 or less, or if values are 5 or less, chromas are less than 2,

(b) if hues are yellower than 2.5Y, moist chromas are 2 or less,

(c) chromas are 1 or less with or without mottles;

(2) have no horizon with dominant chromas of 3 or more within 75 cm (30 inches) of the surface;

b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;

c. have less than 5 percent plinthite in any horizon within 1.5 m (60 inches) of the surface;

d. have no lithic contact within 50 cm (20 inches) of the surface;

e. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

Aeric Ochraquults. Ochraquults like the Typic except for a.

Arenic Ochraquults. Ochraquults like the Typic except for b with or without a, and have textures as coarse or coarser than loamy fine sand throughout the upper 50 cm (20 inches) but not extending below 1 m (40 inches).

Arenic Plinthic Ochraquults. Ochraquults like the Typic except for b and c with or without a, and have textures as coarse or coarser than loamy fine sand throughout the upper 50 cm (20 inches) but not extending below 1 m (40 inches).

Grossarenic Ochraquults. Ochraquults like the Typic except for b with or without a, and have textures as coarse or coarser than loamy fine sand extending to more than 1 m (40 inches).

Plinthic Ochraquults. Ochraquults like the Typic except for c.

Plinthaquults. Aquults that have plinthite that forms a continuous phase or constitutes more than half of the matrix of some subhorizon within 1.25 m (50 inches) of the surface.

Typic Plinthaquults. Plinthaquults that

a. have more than 24 meq CEC/100 g clay (by NH_4OAc) and have a cation retention from NH_4Cl of more than 12 meq/100 g clay in the major part of the argillic horizon (see Oxic horizon for definition of cation retention);

b. have plinthite that forms a continuous phase in or below the argillic horizon.

Oxic Plinthaquults. Plinthaquults like the Typic except for a.

Tropaquults. Aquults that

1. have no plinthite that forms a continuous phase or constitutes more than half of the matrix of any subhorizon within 1.25 m (50 inches) of the surface;

2. have a mean annual soil temperature of 8°C (47°F) or more and have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Haplohumults--Cont.

b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).

Typic Haplohumults. Haplohumults that

a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;

b. are never dry between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as much as 60 consecutive days;

c. have no mottles with chromas of 2 or less within the upper 25 cm (10 inches) of the argillic horizon;

d. have no lithic contact within 50 cm (20 inches) of the mineral soil surface.

Andic Haplohumults. Haplohumults like the Typic except for a.

Xeric Haplohumults. Haplohumults like the Typic except for b.

Palehumults. Humults that

1. have an argillic horizon that in the upper 1 m (40 inches) has less than 10 percent weatherable minerals in the 20 to 200 micron fraction; and

2. have a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletans, or other evidences of clay eluviation.

Typic Palehumults. Palehumults that

a. have more than 24 meq CEC/100g clay (by NH_4OAc) and have a cation retention from NH_4Cl of more than 12 meq/100g clay in the major part of the argillic horizon;

b. have no mottles with chromas of 2 or less within the upper 25 cm (10 inches) of the argillic horizon;

c. are never dry between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as much as 60 consecutive days;

d. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

Humoxic Palehumults. Palehumults like the Typic except for a, and have a mean annual soil temperature of less than 22°C (72°F).

Orthoxic Palehumults. Palehumults like the Typic except for a, and either the mean annual soil temperature is 22°C (72°F) or higher, or the soils are dry in some horizon between 18 and 50 cm (7 and 20 inches) in most years but are not dry for 60 consecutive days or more.

Xeric Palehumults. Palehumults like the Typic except for c, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more, and mean annual soil temperatures of less than 22°C (72°F).

Plinthic Ochreptic Fragiudults. Fragiudults like the Typic except for e and a with or without b and have between the fragipan and the surface a horizon 25 cm (10 inches) or more thick that has:

(1) chromas of 3 or more in the matrix,

(2) no mottles with chromas of 2 or less in the upper 25 cm (10 inches),

(3) very few or no clay skins.

Hapludults. (formerly Normudults) Udults that

1. have no fragipan;

2. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in any horizon within 1.25 m (50 inches) of the surface;

3. have a moist color value of 4 or more in some part of the epipedon, or have an argillic horizon that has a dry color value of 5 or more in some subhorizon, or a moist color value of 4 or more;

4. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by 5°C (9°F) or more;

5. have either or both:

   a. clay distribution with depth such that the percentage of clay decreases from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation,

   b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).

Typic Hapludults.

a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;

b. have no mottles with chromas of 2 or less in the upper 60 cm (24 inches) of the argillic horizon;

c. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;

d. have an argillic horizon thicker than 25 cm (10 inches);

e. have an Ap horizon with a moist color value of 4 or more or with a dry value of 6 or more crushed and smoothed * or the A1 horizon is less than 15 cm (6 inches) thick if its moist color value is lower than 3.5;

f. have no lithic contact within 50 cm (20 inches) of the surface of the mineral soil;

g. have textures finer than loamy fine sand in some part of the argillic horizon, and have an argillic horizon that in at least its upper 25 cm (10 inches) has no lamellae;

h. lack the following combination of characteristics:

   (1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

* Use knife and smooth to eliminate shadows.

Typic Hapludults--Cont.

(2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

(3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control sections;

i. have no interruptions of the argillic horizon by ledges of bedrock within each pedon;

Andic Hapludults. Hapludults like the Typic except for a.

Aquic Hapludults. Hapludults like the Typic except for b.

Arenic Hapludults. Hapludults like the Typic except for c, or c and d.

Humic Hapludults. Hapludults like the Typic except for e.

Lithic Hapludults. Hapludults like the Typic except for f.

Ochreptic Hapludults. Hapludults like the Typic except for d.

Psammentic Hapludults. Hapludults like the Typic except for g, or g and c.

Vertic Hapludults. Hapludults like the Typic except for h, with or without b.

Paleudults. Udults that

1. have both of the following:
   a. an argillic horizon that in the upper 1 m (40 inches) has less than 10 percent weatherable minerals in the 20 to 200 micron fraction, and
   b. a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletans or other evidences of clay eluviation;
2. have no fragipan;
3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Paleudults. Paleudults that

a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the soil surface providing color is not due to uncoated grains of sand. If color is due to uncoated grains of sand, no mottles occur with chromas of 2 or less in the upper 12.5 cm(5 inches) of the argillic horizon;

b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;

c. have no subhorizon with more than 5 percent plinthite nodules within 1.5 m (60 inches) of the surface;

d. have an Ap horizon with a moist color value of 4 or more or with a dry value of 6 or more crushed and smoothed * or the A1 horizon is less than 15 cm (6 inches) thick if its moist color value is lower than 3.5;

e. have textures finer than loamy fine sand in some part of the argillic horizon and have no lamellae in at least the upper 1 m (40 inches) of the argillic horizon

Aquic Paleudults. Paleudults like the Typic except for a.

Aquic Arenic Paleudults. Paleudults like the Typic except for a and b and have a sandy epipedon 50 cm to 1 m (20 to 40 inches) thick.

* Use knife and smooth to eliminate shadows.

Typic Haplustults--Cont.

d. have no mottles with chromas of 2 or less in the upper 25 cm (10 inches) of the argillic horizon.

Ruptic-Lithic Haplustults. Haplustults like the Typic except for a and b.

Paleustults. Ustults that

1. have both of the following:
   a. an argillic horizon that in the upper 1 m (40 inches) has less than 10 percent weatherable minerals in the 20 to 200 micron fraction, and
   b. a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletans or other evidences of clay eluviation;
2. have a moist color value of 4 or more in some part of the epipedon, or have an argillic horizon that has a dry color value of 5 or more in some subhorizon or a moist color of 4 or more;
3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface;
4. have no fragipan.

Typic Paleustults. Paleustults that

a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;

b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;

c. have no horizons with more than 5 percent soft plinthite nodules within 1.5 m (60 inches) of the surface;

d. have an irregular upper boundary of the argillic horizon unless an Ap rests directly on it or the argillic horizon is exposed at the surface.

Aquic Paleustults. Paleustults like the Typic except for a.

Arenic Paleustults. Paleustults like the Typic except for b.

Plinthic Paleustults. Paleustults like the Typic except for c.

Plinthustults. Ustults that

1. have plinthite that forms a continuous phase or constitutes more than half of the matrix within some subhorizon in the upper 1.25 m (50 inches) of the soil.

(Subgroups not developed)

Rhodustults. Ustults that lack a fragipan, and

1. have an epipedon with moist color values of less than 4 in all parts;
2. have an argillic horizon with dry color values of less than 5 in all subhorizons and no more than 1 unit higher than the moist values;
3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in any subhorizon in the upper 1.25 m (50 inches) of the soil;
4. have either or both:
   a. clay distribution with depth such that the percentage of clay decreases from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation;
   b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).

Xerults--Cont.

3. have less than 1.5 percent organic matter (0.87 percent carbon) in the upper 15 cm (6 inches) of the argillic horizon exclusive of any Ap;

4. have less than 20 kg organic matter in a unit volume of 1 m^2 to a depth of 1 m (40 inches) below the base of any O horizon or the mineral surface;

5. are never saturated with water, or have redder hues or higher chromas than Aquults.

Haploxerults. Xerults that

1. have no fragipan;

2. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in any horizon within 1.25 m (50 inches) of the surface;

3. have a moist color value of 4 or more in some part of the epipedon, or have an argillic horizon that has a dry color value of 5 or more in some subhorizon or a moist color value of 4 or more;

4. have either or both:

   a. clay distribution with depth such that the percentage of clay decreases from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation,

   b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).

Typic Haploxerults. Haploxerults that

a. have no mottles with chromas of 2 or less in the upper 25 cm (10 inches) of the argillic horizon;

b. have no lithic contact within 50 cm (20 inches) of the mineral soil surface;

c. have textures finer than loamy fine sand in some part of the argillic horizon and with an argillic horizon that, in at least its upper 25 cm (10 inches), has no lamellae;

d. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

Aquic Haploxerults. Haploxerults like the Typic except for a.

Lithic Haploxerults. Haploxerults like the Typic except for b.

Palexerults. Xerults that

1. have both of the following:
   a. an argillic horizon that in the upper 1 m (40 inches) has less than 10 percent weatherable minerals in the 20 to 200 micron fraction, and
   b. a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletans or other evidences of clay eluviation;
2. have a moist color value of 4 or more in some part of the epipedon, or have an argillic horizon that has a dry color value of 5 or more in some subhorizon or a moist color value of 4 or more;
3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface;
4. have no fragipan.

OXISOLS: ORDER 9

Oxisols are mineral soils that have an oxic horizon at some depth within 2 meters (80 inches) of the surface* or plinthite that forms a continuous phase within 30 cm (12 inches) of the mineral surface of the soil. No spodic or argillic horizon overlies the oxic horizon.

It was pointed out in the 7th Approximation that the classification of the Oxisols had lagged behind that of the other orders of mineral soils. While we have accumulated data on a number of soils of Hawaii and Puerto Rico, the Oxisols are not extensive on these islands and are representative only of the Oxisols from basic rocks in Africa, South America, and Oceania. The classification presented here is an attempt to find a compromise between somewhat contrasting opinions. Probably it will satisfy no one. Yet as we pointed out in the 7th Approximation (page 11), compromises between divergent viewpoints are necessary in a large group of scientists and may actually produce a system with more general utility than a system arising from a single viewpoint. We have attempted to devise a system that can be applied with maximum accuracy in the field with the use of the simple tests that can be made in a field laboratory. The equipment required would include a microscope and stains for micromorphologic and mineralogical examinations, and glassware and chemicals for estimation of the cations retained by soil samples.

The classification of Oxisols that follows seems to produce satisfactory groupings of the limited numbers of the soils that we have in Hawaii and Puerto Rico. It needs to be tested more widely, however, for it is certain to have many shortcomings.

Aquox. Oxisols that have plinthite that forms a continuous phase within 30 cm (12 inches) of the mineral surface of the soil; or that are either saturated with water at some time during the year, or artificially drained, and have an oxic horizon that has one or both of the following characteristics associated with wetness:

1. a histic epipedon;

2. if free of mottles, dominant chromas are 2 or less immediately below any epipedon that has a moist color value of less than 3.5; or if mottled with distinct or prominent mottles within 50 cm (20 inches) of the surface, dominant chromas are 3 or less.

Gibbsiaquox. Aquox that have sheets containing 30 percent or more gibbsite, or 20 percent or more by volume of gravel-size aggregates containing 30 percent or more gibbsite within 1 m (40 inches) of the mineral surface, but that have no plinthite that forms a continuous phase within 30 cm (12 inches) of the soil surface. This group of soils is not known in the United States, and subgroups are not developed. It is believed that the typic subgroup should have gibbsite nodules from the surface down.

Ochraquox. Aquox that have an ochric epipedon, but have no plinthite that forms a continuous phase within the upper 1.25 m (50 inches), and have no sheets of gibbsite or aggregates cemented by gibbsite within the upper 1 m (40 inches). It is believed the typic subgroup should:

a. have properties diagnostic of an oxic horizon at the surface or immediately below any thin surface horizon that has moist color values less than 3.5, and extending to a depth of 1 m (40 inches) or more;

b. have no plinthite that forms a continuous phase within the upper 1 m (40 inches);

c. have textures of sandy clay loam or finer throughout the oxic horizon.

Plinthaquox. Aquox that have plinthite that forms a continuous phase within 1.25 m (50 inches) of the surface. This group is not known in the United States. It is believed the typic subgroup should:

a. have no plinthite that forms a continuous phase within the surface 30 cm (12 inches);

b. have chromas of 2 or less in some part of the matrix of the non-plinthite materials within the horizon that contains plinthite, and in all overlying horizons;

c. have an ochric epipedon.

A superic subgroup is proposed for Plinthaquox that have plinthite that forms a continuous phase at the surface, or within the surface 30 cm (12 inches).

* If the epipedon is thicker then 2 m (80 inches), and is immediately underlain by an oxic horizon, the soil is grouped with the Oxisols.

Typic Acrorthox--Cont.

c. have textures of sandy clay loam or finer in the oxic horizon to a depth of at least 1 m (40 inches).

(Profile 27, p. 92, 7th Approximation, is considered representative of the Typic Acrorthox. Additional data on this profile are given in Table 15, p. 54).

Eutrorthox. Orthox that

1. have in all subhorizons of the oxic horizon a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams of clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams of clay;

2. have base saturation (by NH_4OAc) of 35 percent or more in the epipedon and in all subhorizons of the oxic horizon to a depth of at least 1.25 m (50 inches);

3. have no anthropic epipedon.

Typic Eutrorthox. Eutrorthox that

a. have an oxic horizon that extends to 1.25 m (50 inches) or more below the mineral surface;

b. have no structure in the oxic horizon or have only very weak prismatic or blocky structure.

c. have textures of sandy clay loam or finer in all parts of the oxic horizon within 1.25 m (50 inches) of the mineral surface;

d. have no plinthite (that is not indurated) within 1.25 m (50 inches) of the surface;

e. have no mottles with chromas of 2 or less accompanied by red or dark red mottles within 1.25 m (50 inches) of the surface;

Tropeptic Eutrorthox. Eutrorthox like the Typic except for a or b, or a and b.

Gibbsiorthox. Orthox that

1. have within 1.25 m (50 inches) of the surface, sheets containing 30 percent or more gibbsite or a subhorizon with 20 percent or more by volume of gravel-size aggregates containing 30 percent or more gibbsite.

Typic Gibbsiorthox. Gibbsiorthox that

a. have gravel-size aggregates cemented by gibbsite within the surface 25 cm (10 inches);

b. have no mottles with chromas of 2 or less within the upper 1 m (40 inches), or above the uppermost gibbsite sheet, whichever is shallower.

Haplorthox. Orthox that

1. have a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams of clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams of clay) in all subhorizons of the oxic horizon;

2. have no sheets of gibbsite or gravel-size aggregates cemented by gibbsite within 1.25 m (50 inches) of the surface;

3. have an ochric epipedon and less than 1 percent organic carbon in some subhorizon that is within 75 cm (30 inches) of the mineral surface;

4. have base saturation (by NH_4OAc) of less than 35 percent in some subhorizon of the oxic horizon within 1.25 m (50 inches) of the mineral surface.

Typic Haplorthox. Haplorthox that

a. have no mottles with chromas of 2 or less accompanied by red or dark red mottles within 1.25 m (50 inches) of the surface;

Typic Haplorthox--Cont.

b. have no plinthite (that is not indurated) within 1.25 m (50 inches) of the surface;

c. have textures of sandy clay loam or finer in all parts of the oxic horizon within 1.25 m (50 inches) of the mineral surface;

d. have an oxic horizon that extends to 1.25 m (50 inches) or more below the mineral surface;

e. have no structure in the oxic horizon or have only very weak prismatic or blocky structure.

Aquic Haplorthox. Haplorthox like the Typic except for a.

Plinthic Haplorthox. Haplorthox like the Typic except for b.

Psammentic Haplorthox. Haplorthox like the Typic except for c.

Tropeptic Haplorthox. Haplorthox like the Typic except for d or e or d and e.

Umbriorthox. Orthox that

1. have a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams of clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams of clay) in all subhorizons of the oxic horizon;

2. have no sheets of gibbsite or gravel-size aggregates cemented by gibbsite within 1.25 m (50 inches) of the surface;

3. have either an umbric epipedon or an ochric epipedon that has more than 1 percent carbon in all subhorizons to 75 cm (30 inches) or more below the top of the mineral surface;

4. have base saturation (by NH_4OAc) of less than 35 percent in some subhorizon of the oxic horizon within 1.25 m (50 inches) of the mineral surface.

Typic Umbriorthox. Umbriorthox that

a. have textures of sandy clay loam or finer in all parts of the oxic horizon within 1.25 m (50 inches) of the mineral surface;

b. have an oxic horizon that extends to 1.25 m (50 inches) or more below the mineral surface;

c. have no plinthite (that is not indurated) within 1.25 m (50 inches) of the surface;

d. have no mottles that have chromas of 2 or less accompanied by red or dark red mottles within 1.25 m (50 inches) of the surface;

e. have an umbric epipedon less than 1.25 m (50 inches) thick and have less than 1 percent carbon in some subhorizon within 1.25 m (50 inches) of the mineral surface.

Torrox. Oxisols that

1. are usually dry in most years in all parts of the soil between the Ap horizon or 18 cm (7 inches) and 2 m (80 inches) or a lithic or a paralithic contact, whichever is shallower;

2. have an ochric epipedon that has moist color values of 4 or more in all subhorizons.

Torrox are not known to occur in the United States. The suborder may not be needed and is suggested tentatively. It is possible that no subdivisions of the suborder will be needed at the great group level unless wide variations are found to exist in base saturation or base retention. The typic subgroup should probably have textures of sandy clay loam or finer throughout the oxic horizon.

Ustox. Oxisols that

1. have some subhorizon below the surface 18 cm (7 inches) that is dry for 60 consecutive days or more in most years;

Ustox--Cont.

2. have mean annual soil temperatures of 15°C (59°F) or more;

3. either have moist values of less than 4 in some part of the epipedon (A1 or Ap) or are usually moist.

Acrustox. Ustox that

1. have a cation retention capacity (from NH_4Cl) of 1 meq or less per 100 grams clay in some subhorizon of the oxic horizon (or have 1 meq or less of extractable bases plus extractable aluminum per 100 grams clay);

2. have an umbric or ochric epipedon;

3. have no discernible structure in the oxic horizon or have only very weak blocky or prismatic structure.

Typic Acrustox. Acrustox that

a. have no plinthite or gravel-size aggregates cemented by gibbsite within 1 m (40 inches) of the surface;

b. have an oxic horizon that extends to 2 m (80 inches) or more below the top of the mineral surface;

c. have textures of sandy clay loam or finer in the oxic horizon to a depth of at least 1 m (40 inches).

Eutrustox. Ustox that

1. have a mollic or umbric epipedon that is at least one unit of value darker (moist) or one or more units of chroma lower (moist) than the oxic horizon and base saturation of 50 percent or more (by NH_4OAc) in the oxic horizon if the particle size class is clayey, or 35 percent or more if the particle-size class is loamy;

2. have a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams clay) in all subhorizons of the oxic horizon;

We would propose the following definition for the typic subgroup:

Typic Eutrustox. Eutrustox that

a. have textures of sandy clay loam or finer in all parts of the oxic horizon;

b. have an oxic horizon that extends to 1.25 m (50 inches) or more below the surface;

c. have no plinthite (that is not indurated) within 1.25 m (50 inches) of the surface;

d. have no mottles with chromas of 2 or less accompanied by red or dark red mottles within 1.25 m (50 inches) of the surface;

e. have no structure in the oxic horizon, or have only weak blocky or prismatic structure.

Haplustox. Ustox that

1. have a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams of clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams clay)in all subhorizons of the oxic horizon;

2. have no mollic epipedon, or a mollic epipedon that is less than 1 unit of value darker and has chromas that differ by less than 1 unit (moist colors) from the oxic horizon;

3. have base saturation (by NH_4OAc) of less than 50 percent in some part of the oxic horizon if the particle-size class is clayey and less than 35 percent if the particle-size class is loamy.

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